148

Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JANUARY 1953

Stop This!

foam costs money . . . it adversely affects the appearance and formation of the sheet. Further, it can cause breaks on the machine or slower machine speeds, resulting in lost production. Foam can also cost added dollars in plant housekeeping and safety.

Hercules offers a complete line of rapid-acting defoamers and eveners for paper and paper coatings, including the first defoamer to be made in convenient, solid brick form.

Write for details, describing your foaming problems. Our technical service staff will be glad to work with you in selecting the right material for the job.

Paper Makers Chemical Department

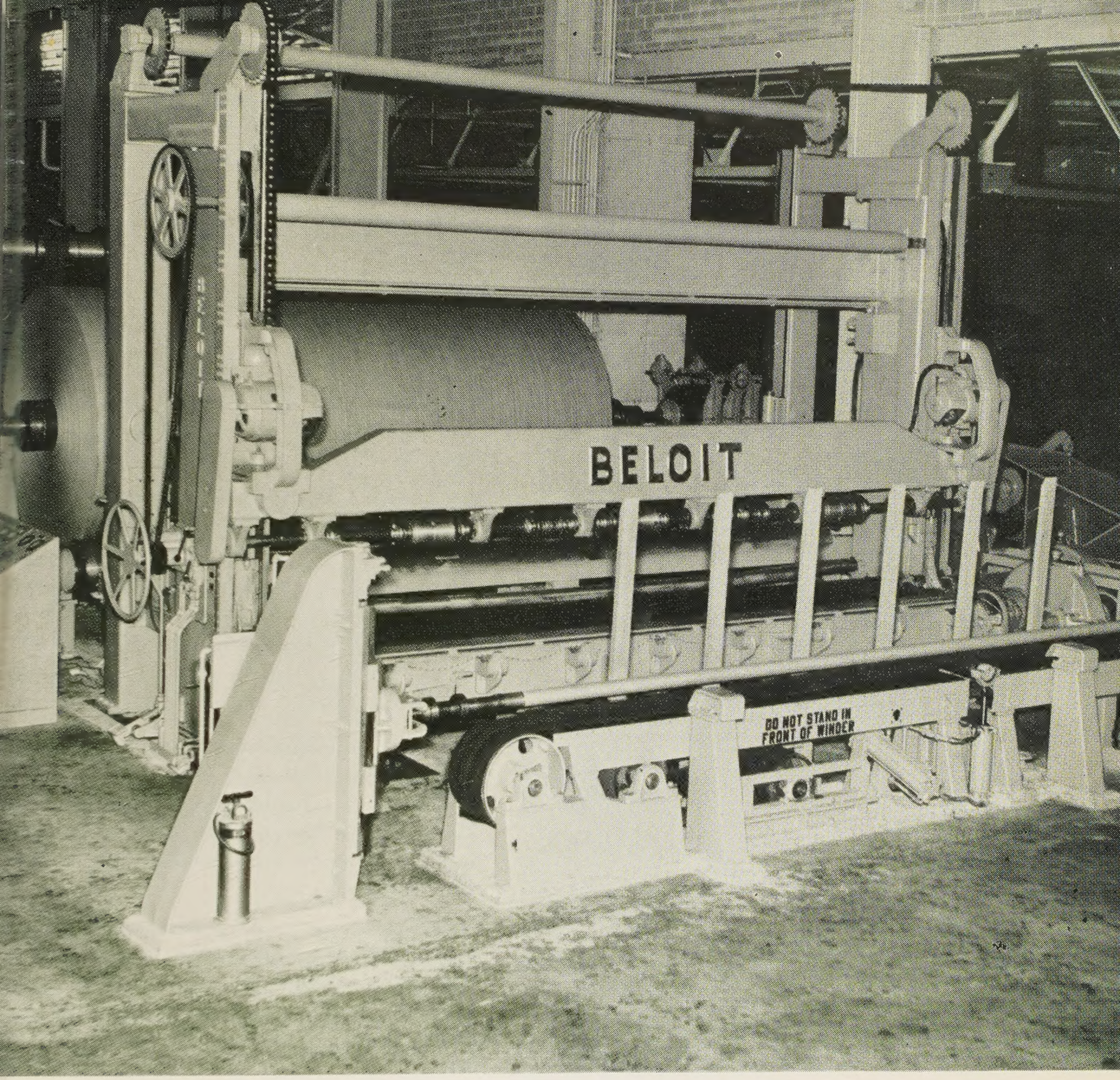
HERCULES POWDER COMPANY

INCORPORATED

967 King Street, Wilmington 99, Delaware

SIZING MATERIALS AND CHEMICALS FOR PAPE

PP53



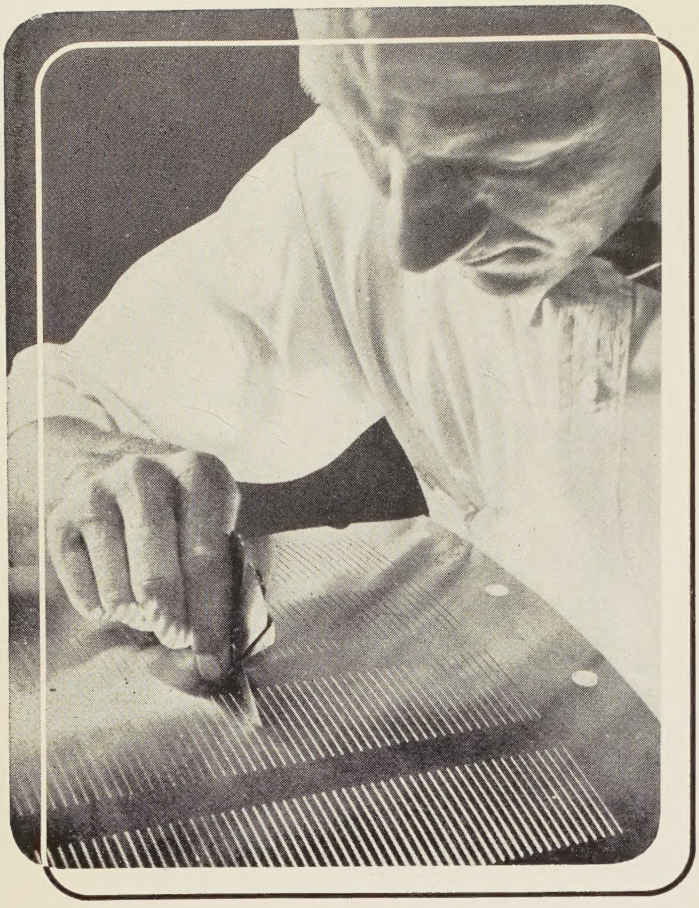
Crossett Paper Mills, Crossett, Ark.

INTEGRATED OPERATION by this Beloit Winder makes hundreds of sets of counter rolls from 88-inch parent rolls during an eight-hour shift. From the driven unwind stand to the efficient roll-handling equipment, every detail has been designed for high-speed production. A pre-set cycle of winder operation, started by a "run" pushbutton, automatically completes rolls of the desired size.—*Beloit Iron Works, Beloit, Wisconsin.*

BELOIT

PAPER MACHINERY

WHEN YOU BUY BELOIT... YOU BUY MORE THAN A MACHINE!



Inspector gauges screen plate slot for precise .014 accuracy. Further microscopic examination double-checks careful fabrication at Union Screen Plate Company.

how method plus material give screen plates longer life

It takes science's tools in craftsmen's hands to do the careful finishing that adds months to screen plate service life.

And it takes a screen plate metal that doesn't crumble away in corrosive mill stocks.

That's why Union Screen Plate Company checks and rechecks finishing operations with caliper, feeler gauge and microscope. And that's why they recommend Inconel when other metals are giving unsatisfactory service.

And why Inconel?

First, because Union's engineers have found that Inconel resists corrosion.

Inconel plates in one rag paper mill showed no measurable slot enlargement from corrosion after three years of service. Plates of other materials often gave trouble within a year.

Second, Inconel is strong. In some cases 3/16-inch screen plates of the usual metals have been replaced by Inconel two-thirds as thick!

Third, it is fatigue-resisting and withstands severe vibration and shock.

And fourth, Inconel means smoother plant operation. Because Inconel plates do not rust or pit, surface stays smooth . . ."strings" of fibers do not build up . . . there's less hand cleaning . . . fewer shut-downs or stoppages. Unvarying slot dimensions keep screening efficiency high, rejects at a minimum.

All in all, Inconel screen plates measure up to years of extra service . . . with less trouble . . . at lower yearly costs. For additional information about Inconel screen plates, write to the Union Screen Plate Co., Fitchburg, Mass.

Today, Inconel, like the other Nickel Alloys, is on extended delivery because so much is needed for defense. Therefore, it pays to anticipate needs. Always order well in advance giving NPA rating and complete end-use information.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

Inco Nickel Alloys

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL "S"® MONEL • NICKEL • LOW CARBON NICKEL • DURANICKEL® INCONEL® • INCONEL "X"® • INCOLOY • NIMONICS®

IMPROVED DRAPE—SOFT FEEL—OUTSTANDING TOUGHNESS

KRAFT PAPERS

GET IMPROVED CHARACTERISTICS

WITH BEATER-IMPREGNATED CHEMIGUM LATEX

This kraft paper has a soft look—but it's *tough*, with a cloth-like rubbery stretch and an edge tear improved up to 40% over the original kraft. Reason for the improvement is the addition of CHEMIGUM Latex to the pulp in the beater. CHEMIGUM Latex is the water dispersion of a nitrile-type rubber—the most resistant to oils and solvents.

Details of application were:

Stock 40 lb. basis weight (24 x 36–500) medium beaten Scandinavian unbleached kraft pulp (results depend greatly on type of stock used).

Production Latex as received was added to the beaten pulp without any special sensitizing process. Alum precipitated the rubber onto the paper fibers. No expensive solvent recovery system or heat treating equipment was required. Regular equipment was used with no plugging of screens or other difficulties.

End Results Edge tear improved up to 40% over non-impregnated stock. Improved drape and soft, flexible feel imparted to heavy kraft. No stiffness or boardy feel. Stock has cloth-like, rubbery stretch.

Wherever latex impregnation of paper stocks can assist you, it will pay you to bring your specific technical problems to:

Goodyear, Chemical Division
Akron 16, Ohio

CHEMICAL GOODYEAR DIVISION

Chemigum, Pliobond, Pliolite, Pliovic—T.M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

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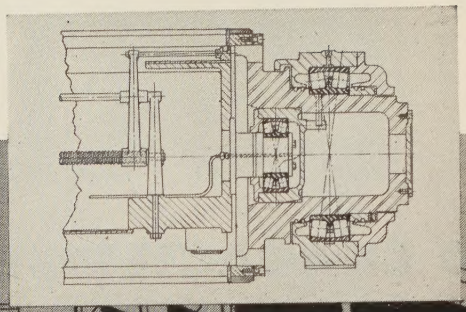
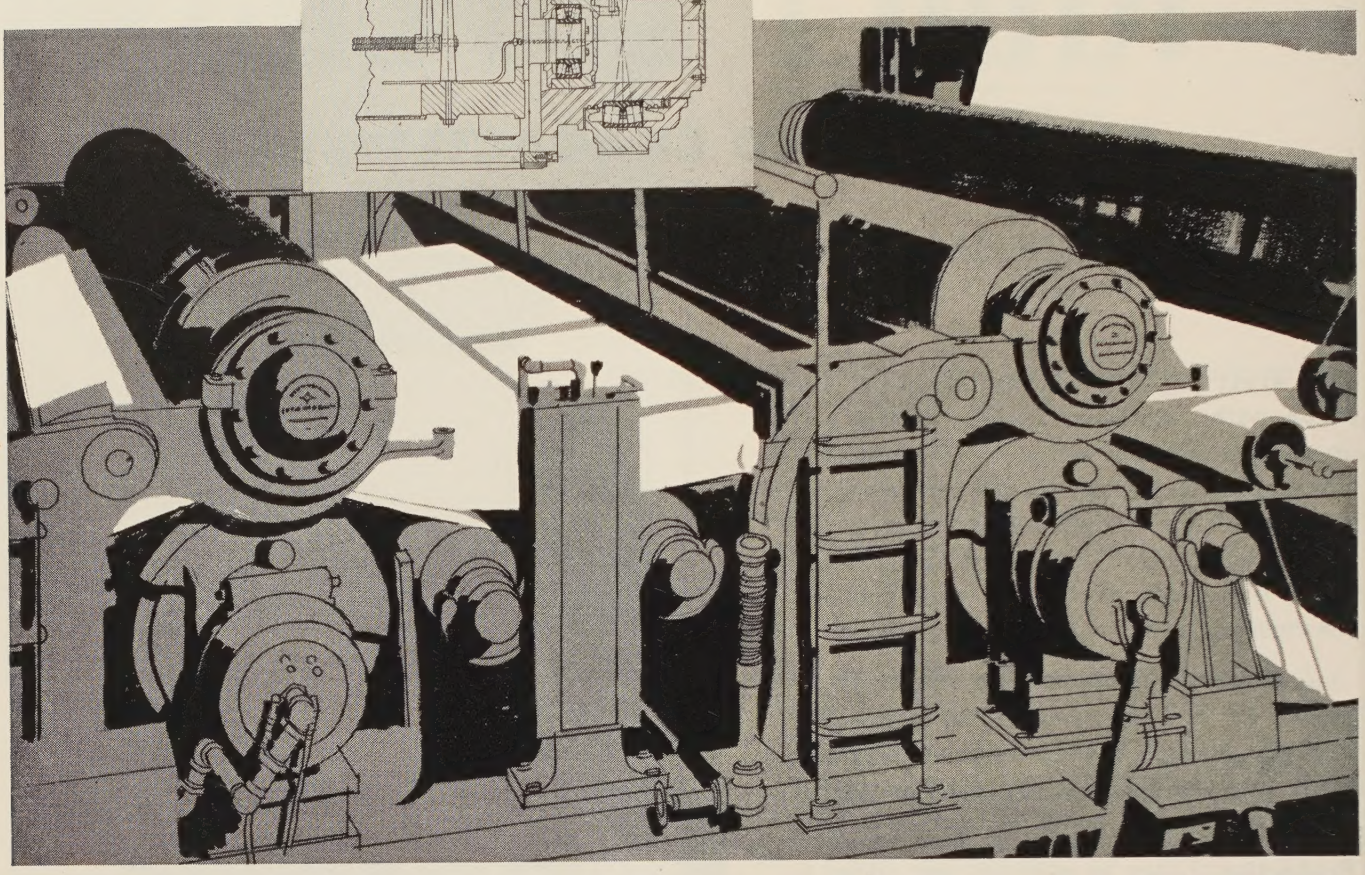
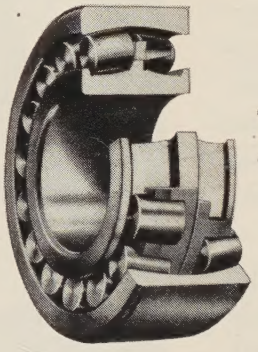


Self-aligning TORRINGTON Spherical Roller Bearings are used on all press rolls in this latest high-speed Fourdrinier kraft machine. This machine is completely TORRINGTON equipped.



Speeding today's paper production!



Modern high-speed paper machines demand the best in bearings.

That's why so many of them are equipped with TORRINGTON Spherical Roller Bearings.

TORRINGTON Spherical Roller Bearings are self-aligning. They compensate for journal deflection and out-of-squareness of machine framing. They simplify installation, eliminate all need for periodic alignment adjustment.

TORRINGTON Spherical Roller Bearings have cast-bronze *land-riding* cages. They roll smoothly and efficiently at top speed and assure uniform draw.

And like *all* TORRINGTON Bearings, TORRINGTON Spherical Roller Bearings are *precision-ground*. Conformity factors are uniformly high. Quality of surface finish is unsurpassed.

Specify the best for your own paper machines. Specify TORRINGTON Spherical Roller Bearings.

THE TORRINGTON COMPANY

Torrington, Conn. South Bend 21, Ind.

TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Needle • Tapered Roller • Straight Roller • Ball • Needle Rollers

JANUARY 1953

Tappi

VOL. 36 · NO. 1

Published monthly by the Technical Association of the Pulp and Paper Industry

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TECHNICAL ARTICLES

Concepts of Quality Control, *by W. R. Purcell* 1
Color Precursors in Spruce- and Western Hemlockwoods, *by Ward Pigman, Ernest Anderson, R. Fischer, M. A. Buchanan, and B. L. Browning* 4
Methods of Increasing the Efficiency of Wet-Strength Resins, *by J. Vernon Kindall and John B. Davidson* 12
The Chemical Composition of the Bast Fibers of Douglas-Fir Bark, *by Harry J. Kiefer and E. F. Kurth* 14
Performance of Paper Machine Wet Felts. II. Further Studies of the Plugging of Felts, *by David W. French* 20
The Stiffness of Paper. NBS Stiffness Tester, *by F. T. Carson and Vernon Worthington* 36
A Liquid Penetration Test for Measuring the Sizing of Paper, *by Donna Price, R. H. Osborn, and J. W. Davis* 42
Guar Mannogalactan Studies. I. Purification and Characterization of Purified Fraction, *by Arthur J. Haug* 47
Guar Mannogalactan Studies. II. Effect of Certain Variables, Including Borax, on the Rate of Oxidation of the Purified Mucilage, *by Arthur J. Haug* 53
Guar Mannogalactan Studies. III. Characterization of the Oxidized and Hydrolyzed Mucilage, *by Arthur J. Haug* 59
Guar Mannogalactan Studies. IV. Conversion of Purified Mucilage for Tub-Size Adhesive, *by Arthur J. Haug* 62

DEPARTMENTS

TAPPI Annual Meeting Program ..... 10 A
Self Defense for Your Product—Protective Packaging with Aluminum Foil, *by W. J. Faymonville* ..... 18 A
Papers Presented at the 1952 Corrugating Conference ..... 38 A
Registration of Professional Engineers ..... 64 A
Association News and Events ..... 71 A
Personal Mention ..... 79 A
Obituary ..... 98 A
Letters to the Editor ..... 98 A
Divisions and Committees ..... 100 A
Paper and Packaging Specifications ..... 107 A
Local Section Activities ..... 108 A
Use of Electronic Gages to Determine the Fatigue Point in Corrugated Containers, *by C. S. Macnair* ..... 138 A
Pulps from Straw and Sugarcane Bagasse for Manufacture of Newsprint, *by E. C. Lathrop* ..... 142 A
Paper Machine Fires, *by G. W. Brahmst* ..... 144 A
Employment Service ..... 147 A
Recent Books ..... 147 A
Calendar of TAPPI Meetings ..... 149 A

Published monthly by the Technical Association of the Pulp and Paper Industry at 20th and Northampton Streets, Easton, Pa. Editorial and advertising offices, 122 East 42nd Street, New York 17, N. Y. Articles for publication and communications regarding the editorial content of *Tappi* should be addressed to the Editor at the editorial office. Statements and opinions expressed in articles and editorials appearing in *Tappi* are those of the contributors, and the Technical Association of the Pulp and Paper Industry assumes no responsibility for them. Subscription: U. S. and possessions $7.50; Canada $8.25; Pan American Union $9.00; Other Foreign $10.00. Single copies to members of TAPPI $0.75; Nonmembers $1.00. Entered as second class matter January 27, 1949, at the Post Office at Easton, Pa., under the act of August 24, 1912. Copyright, 1953, by the Technical Association of the Pulp and Paper Industry. An index of the technical articles appearing in the magazine appears in the Industrial Arts Index and the Engineering Index.

production increased up to 15 tons per day...

... with W & T chlorination equipment

A Southern mill had been having trouble with paper breaks attributable to the presence of slime in their white water. Despite continued efforts to control them slime breaks were running 60 to 80 per week, resulting in a time loss of 10 to 14 hours per week, and an average production loss of 15 tons per day! It was then that the W&T man was called in.
Where and how to apply the proper treatment was determined, the costly methods were discontinued, and W&T chlorination was installed.

During the first 3 days of chlorination the mill recorded only 1 slime break and 2 minutes of lost time.

During the next 3 days there were 4 breaks and 17 minutes of lost time.

During the next 25 days there were no breaks attributable to slime!

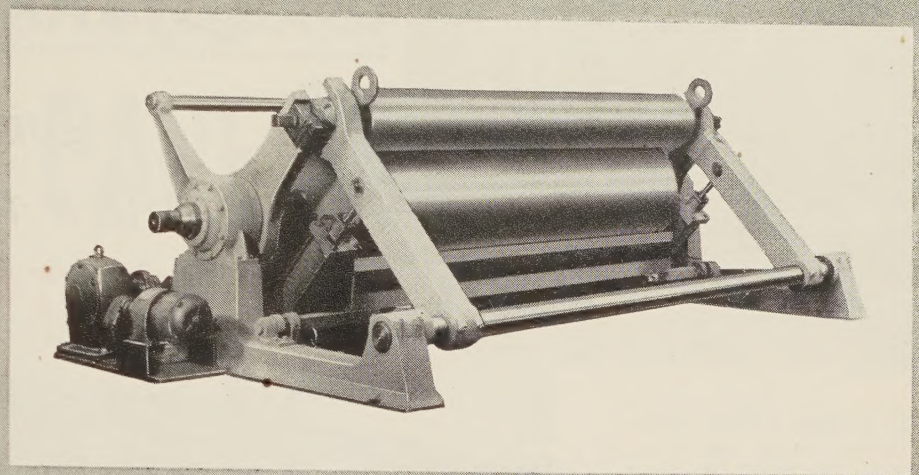
. . . Within a week there were no production losses caused by slime!
Performance such as that is typical of what your W&T representative can do for you.

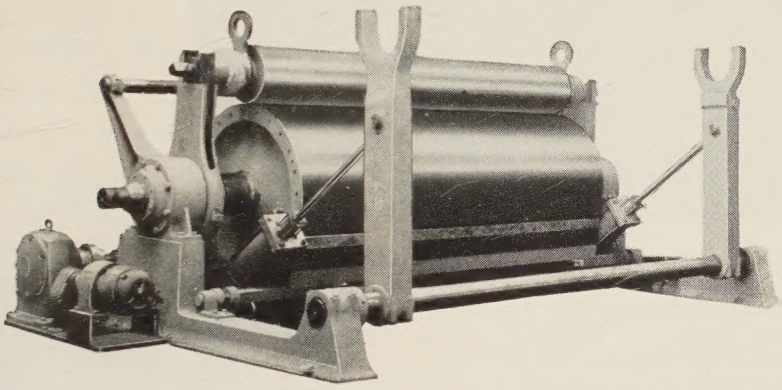
If you have a production problem attributable to impure water, it would pay you to write or call him now.

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

I-42

an improved and simplified reel by Black-Clawson





Here is a Black-Clawson improved and simplified uniform-speed reel. Take a look at it.

This reel is designed for simplicity and for complete control by the operator.

Air cylinders on the secondary arms control the pressure and uniformity of the winding roll on the reel drum face. The motor-operated primary arms provide easy transfer of the reel spool to the secondary arms.

The Doctor is air-operated for quick in and out contact with reel drum to prevent sheet wrap of drum during reel changes.

It is definitely a push-button controlled reel and it can be built to wind rolls for any and all requirements.

For technical description, get in touch with the Black-Clawson Hamilton Division.

The Black-Clawson Co., Hamilton, Ohio

SHARTLE BROS. MACHINE CO., Middletown, Ohio • DILTS MACHINE WORKS, Fulton, New York
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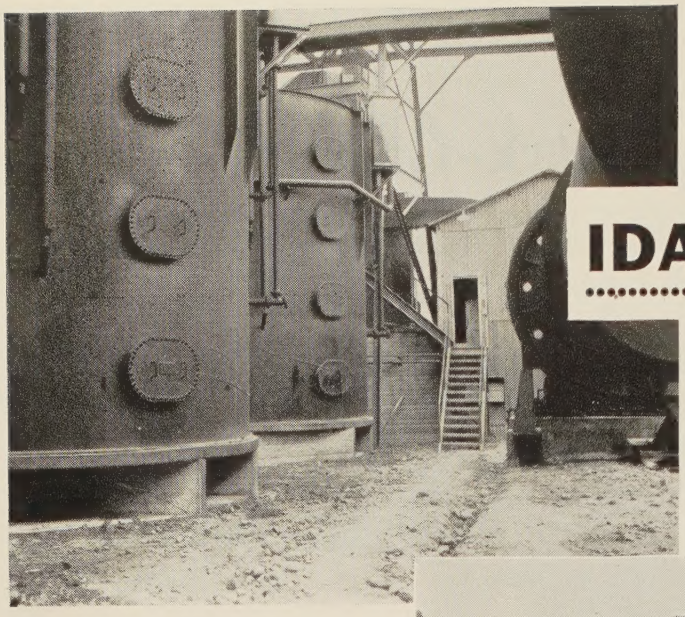
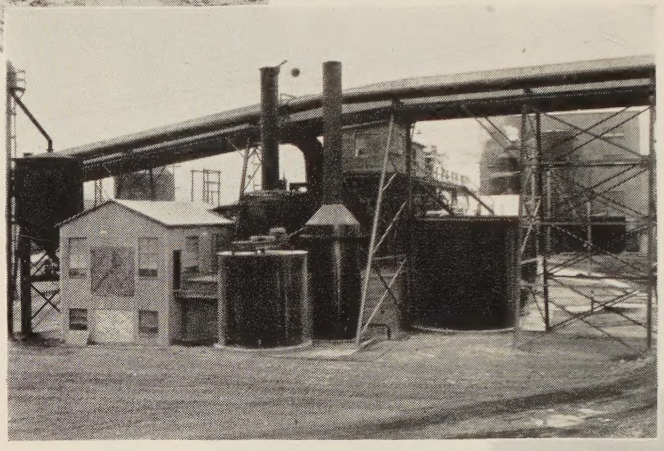


IDAHO KRAFT MILL

TURNS WASTE WOOD INTO NEW PROFITS

22-ft. diam. by 24-ft. white liquor clarifier and 22-ft. diam. by 24-ft. lime mud washer built by the Chicago Bridge & Iron Company for Potlatch Forests, Inc. at Lewiston, Idaho.



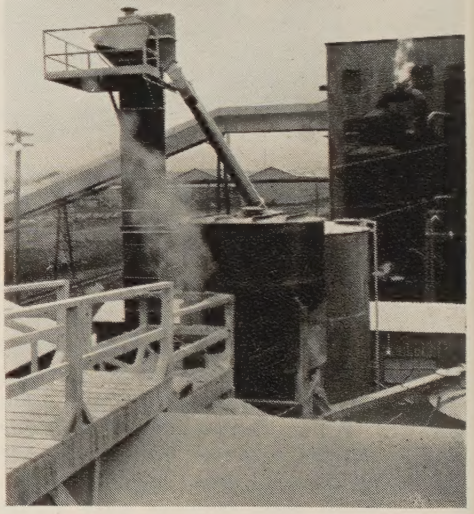
General view of recausticizing plant showing 15-ft. diam. by 15-ft. agitator tank in the left foreground. This unit was built for Potlatch Forests, Inc. by the Chicago Bridge & Iron Company.

GREATER utilization of timber lands has resulted in greater product diversification and new profits for Potlatch Forest, Inc. of Lewiston, Idaho. Instead of burning wood waste resulting from the operation of their white pine saw mill, this progressive company decided to utilize it to make pulp. They built a 150-ton bleached kraft pulp and paper mill near the saw mill and are turning the waste wood into machine dried pulp, bleached container board, bleached tag stock, and unbleached kraft.

Playing an important part in the operation of the Potlatch pulp and paper mill are a number of Horton* digesters and other steel plate structures. They were all built to exacting specifications by the Chicago Bridge & Iron Company and, once again, illustrate our versatility in fabricating all types of steel plate equipment for the pulp and paper industry. If your mill is expanding or replacing worn out steel plate structures such as digesters, consider the advantage of our experience. We also have five strategically located plants, and our facilities for stress relieving and x-raying are complete.

Write our nearest office for details. There is no obligation.

** Trade mark registered in U. S. Patent Office*



10-ft. diam. by 10-ft. lime storage tank built of stainless steel at the Lewiston mill. It has a 45 deg. cone bottom and is supported on 4 columns, 17 ft. above the ground.

CHICAGO BRIDGE & IRON COMPANY

Atlanta, 3 . . . . . 2133 Healey Building
Birmingham, 1 . . . . . 1543 North 50th Street
Boston, 10 . . . . . 1057—201 Devonshire Street
Chicago, 4 . . . . . 2140 McCormick Building
Cleveland, 15 . . . . . 2238 Midland Building
Detroit, 26 . . . . . 1548 Lafayette Building
Havana . . . . . 402 Abreu Building
Houston, 2 . . . . . 2156 National Standard Building
Los Angeles, 17 . . . . 1550 General Petroleum Building
New York, 6 . . . . . 3324—165 Broadway Building
Philadelphia, 3 . . . 1642—1700 Walnut Street Building
San Francisco, 4 . . . . . 1538—200 Bush Street
Seattle, 1 . . . . . 1362 Henry Building
Tulsa, 3 . . . . . 1645 Hunt Building

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY, and GREENVILLE

In Canada: HORTON STEEL WORKS, Limited, FORT ERIE, ONT.

WHEN IT'S RELEASE YOU WANT IN PAPER

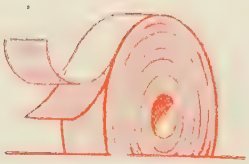
Du Pont "Quilon" is the answer!

When you treat paper with Du Pont "Quilon" stearato chromic chloride, you give it release qualities of unusual functional value. Yet the cost is low because the amount of "Quilon" needed is so small. And the treatment is permanent because "Quilon" is non-migratory—anchors tightly to the fibers of paper.

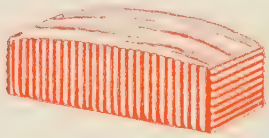
"Quilon" is water-soluble and easily applied by spray, transfer rolls or immersion. Treatment can be done at the size press or, for heavyweight papers, at calender stack water boxes. "Quilon" doesn't give paper a waxy feel . . . doesn't adversely affect any dry properties of paper.

"Quilon" also provides outstanding water repellency and size

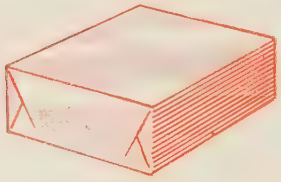
"Quilon" can be used to impart a high degree of size and water repellency to paper. And as a pre-treatment for wax-coated paper, "Quilon" increases lactic-acid resistance. It also has wide application for minimizing undesirable water sensitivity of many soluble coatings and adhesives.



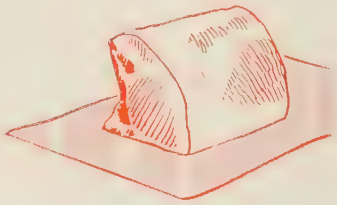
For rubber-separator papers, pressure-sensitive tapes and labels, "Quilon" makes possible easy stripping.



For bakery tray and pan liners, "Quilon" greatly reduces sticking of baked goods.



For frozen-food packages and locker wrap, "Quilon" eliminates fiber pull when frozen-food packages are separated and when frozen food is removed from wrap.



For butcher's wrap and meatboard, "Quilon" reduces sticking, keeps paper from tearing when unwrapped.

Improved products, greater sales. The novel properties and amazing versatility of Du Pont "Quilon" may help you increase your sales of standard products or make superior new products. Send for the technical bulletin . . . it gives more facts and figures on uses and methods of application.

"Quilon" is a registered trade mark of E. I. du Pont de Nemours & Co. (Inc.)

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Grasselli Chemicals Department
Wilmington, Delaware

Please send me free technical bulletin describing "Quilon" stearato chromic chloride.

Name_____ Title_____

Firm_____

Address_____

City_____ State_____

TAPPI Annual Meeting Program

Commodore Hotel, New York, N. Y., February 16–19, 1953

MONDAY, FEBRUARY 16, 1953

10:00 a.m. First General Session (East Ball Room)

K. P. GEOHEGAN, President of TAPPI, Howard Paper Mills, Inc., Dayton, Ohio, *Chairman*

1. Secretary's Report, by R. G. MACDONALD.
2. President's Address, by K. P. GEOHEGAN.
3. Report of the Tellers Committee.
4. Report of Joint Text Book Committee, by R. S. KELLOGG, *Secretary*.
5. "Building a Library Collection for the Pulp and Paper Curriculum at Western Michigan College of Education," by Taisto J. Niemi, Western Michigan College, Kalamazoo, Mich.

9:15 a.m. Wax Testing Committee (Room C)

2:00 p.m. Committee Meetings (Grand Ball Room)

All committee meetings will be held in the Grand Ball Room unless otherwise indicated. Any member of the Association who would like to participate actively in the work of any of the committees should write to the committee chairman prior to the meeting and express a desire to be present at the committee meeting. Tables assigned to committees will be designated by poster cards.

Research Development Division (Grand Ball Room)

W. F. HOLZER, Crown Zellerbach Corp., Camas, Wash., *General Chairman*

- Statistics Committee—JOHN F. LANGMAID, JR., *Chairman*, S. D. Warren Co., Cumberland Mills, Me.
- Microbiological Committee—R. F. DE LONG, *Chairman*, Marathon Corp., Rothschild, Wis.

Industrial Division (Grand Ball Room)

R. W. KUMLER, American Cyanamid Co., New York, N. Y., *General Chairman*

- Nonfibrous Raw Materials Committee—E. N. POOR, Hudson Pulp & Paper Co., Augusta, Me., *Chairman*
- Water Committee—WILLIAM D. RICE, *Acting Chairman*, P. H. Glatfelter Co., Spring Grove, Pa.
- Fibrous Agricultural Residues Committee—S. I. ARONOVSKY, *Chairman*, Northern Regional Research Laboratory, Peoria, Ill.
- Structural Fibrous Materials Committee (10 subcommittees)—E. M. JENKINS, *Chairman*, Johns-Manville Research Center, Manville, N. J.
  - New Projects and Review Subcommittee (S-1)—J. O. BURTON, *Chairman*, Minnesota & Ontario Paper Co., International Falls, Minn.
  - Paper, Publication, and Review Subcommittee (S-2)—J. F. CAMPBELL, *Chairman*, Flintkote Co., Meridian, Miss.
  - Test Board Formation Subcommittee (S-3)—R. G. LACEY, *Chairman*, Celotex Co., Marero, La.
  - Drainage Time Testing Subcommittee (S-4)—J. J. PEROT, *Chairman*, Flintkote Co., Whippany, N. J.
  - Transverse and Deflection Testing Subcommittee (S-5)—J. F. CAMPBELL, *Chairman*
  - Water Absorption, Water Penetration, and Water Vapor Permeability Subcommittee (S-6)—A. T. WALTON, *Chairman*, Simpson Logging Co., Shelton, Wash.
  - Nail Holding and Racking Test Subcommittee (S-7)—T. C. DUVAL, *Chairman*, Wood Conversion Co., Cloquet, Minn.
  - Light Reflection Measurement Subcommittee (S-8)—W. L. SCOTT, *Chairman*, Armstrong Cork Co., Lancaster, Pa.
  - Consistency Measurements of Insulating Board Pulps Subcommittee (S-9)—A. H. CHAMBERLAIN, *Chairman*, Bird & Son, Phillipsburg, R. I.
  - Test Board vs. Hand Sheets for Board Pulp Evaluation Subcommittee (S-10)—C. K. TEXTOR, Bauer Bros. Co., Springfield, Ohio

Converting and Consuming Division (East Ball Room)

L. K. BURNETT, Ohio Boxboard Co., Rittman, Ohio, *General Chairman*

- Graphic Arts Committee—F. D. ELLIOTT, *Chairman*, Time, Inc., Springdale, Conn.
- Coating Committee—J. H. HEUER, *Chairman*, Great Northern Paper Co., Millinocket, Me.
- Wet Strength Committee—K. W. BRITT, *Chairman*, Scott Paper Co., Chester, Pa.
- Plastics Committee—E. C. JAHN, *Chairman*, College of Forestry, State University of New York, Syracuse, N. Y.
  - Fabrication and Structural Products Subcommittee—R. L. GRIFFITH, *Chairman*, Mica Insulator Co., Schenectady, N. Y.
  - Plastics in Paper Converting Subcommittee—R. T. NAZZARO, *Chairman*, Westfield River Paper Co., Russell, Mass.
  - Resin Analysis Subcommittee—S. EARLL CHURCH, *Chairman* College of Forestry, Syracuse, N. Y.
  - Cellulosic Materials Subcommittee—F. A. SIMMONDS, *Chairman*, Forest Products Laboratory, Madison, Wis.
  - Resins Advisory Subcommittee—HERMAN F. MARK, *Chairman*, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Pulp Manufacture Division (Grand Ball Room)

K. O. ELDERKIN, Bowater's Southern Paper Co., Calhoun, Tenn., *General Chairman*

- Alkaline Pulping Committee—R. R. FULLER, *Chairman*, Gulf States Paper Co., Tuscaloosa, Ala.
- Mechanical Pulping Committee—F. W. O'NEIL, *Chairman*, College of Forestry, State University of New York, Syracuse, N. Y.
- Chemical Products Committee—ARTHUR POLLAK, *Chairman*, Consulting Engineer, New York, N. Y.
- Pulp Purification Committee—R. F. MCEWEN, *Chairman*, Buffalo Electro-Chemical Co., Buffalo, N. Y.
- Acid Pulping Committee—E. H. WOODRUFF, *Chairman*, Rayonier, Inc., Port Angeles, Wash.
- Semichemical Pulping Committee—J. N. MCGOVERN, Forest Products Laboratory, Madison, Wis.
- Paper Deinking Committee—J. J. FORSYTH, *Chairman*, International Paper Co., Niagara Falls, N. Y. (Room E)

Paper Manufacture Division (Grand Ball Room)

R. P. PRICE, Hammermill Paper Co., Erie, Pa., *General Chairman*

- Preparation of Papermaking Materials Committee—F. S. KLEIN, *Chairman*, Byron Weston Co., Dalton, Mass.
- Papermaking (Cylinder) Committee—J. J. HARRISON, Michigan Carton Co., Battle Creek, Mich. (Room G)
- Papermaking (Fourdrinier) Committee—N. R. PHILLIPS, *Chairman*, Champion Paper & Fibre Co., Canton, N. C. (Room F)

Testing Division (West Ball Room)

J. D'A CLARK, Consultant, Longview, Wash., *General Chairman*

- Nonfibrous Materials Testing Committee—J. P. CASEY, *Chairman*, A. E. Staley Mfg. Co., Decatur, Ill.
- Pulp Testing Committee—R. I. THIEME, *Chairman*, Soundview Pulp Co., Everett, Wash.
- Optical Properties Committee—H. E. OBERMANNS, *Chairman*, Hammermill Paper Co., Erie, Pa.
- Microscopy Committee—C. E. BRANDON, *Chairman*, Howard Paper Mills, Inc., Dayton, Ohio
- Paper Testing Committee—D. H. NEWCOMB, *Chairman*, Riegel Paper Corp., New York, N. Y.
- Packaging Materials Testing Committee—L. E. SIMERL, *Chairman*, Marathon Corp., Menasha, Wis.
- Chemical Methods Committee—A. S. O'BRIEN, *Chairman*, Eastman Kodak Co., Rochester, N. Y.
- Wax Testing Committee (Room C)

Note: Reports of committee chairmen will be given at this session.

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Engineering Division (Room A)

C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y., *General Chairman;* W. C. Bloomquist, General Electric Co., Schenectady, N. Y., *General Secretary*

Steam and Power Committee—Wilfred Wyburn, *Chairman*, Federal Paper Board Co., Bogota, N. J.
Materials Handling Committee—A. P. Schnyder, *Chairman*, Ebasco Services, Inc., New York, N. Y.
Chemical Engineering Committee—J. R. Lientz, *Chairman*, Union Bag & Paper Corp., Savannah, Ga.
Mill Maintenance and Materials Committee—H. F. Parker, *Chairman*, New York & Pennsylvania Co., Lock Haven, Pa.
Mill Design and Economic Aspects Committee—R. A. Packard, *Chairman*, Mutual Security Agency, Washington, D. C.
Engineering Research and Machine Design Committee—J. D. Lyall, *Chairman*, Armstrong Cork Co., Lancaster, Pa.
Electrical Engineering Committee—Ray Foster, *Chairman*, Champion Paper & Fibre Co., Canton, N. C.
Data Sheets Committee—H. J. Perry, *Chairman*, American Paper & Pulp Assoc., New York, N. Y.
Drying and Ventilating Committee—C. A. Young, *Chairman*, Riegel Paper Corp., Milford, N. J.

TUESDAY, FEBRUARY 17, 1953

9:15 a.m. Corrugated Containers (Grand Ball Room)

Panel Session—"Corrugated Liner Web Printing"

D. P. McNelly, Fort Wayne Corrugated Paper Co., Fort Wayne, Ind., *Moderator*

9:15 a.m. Water (Room B-C)

William D. Rice, P. H. Glatfelter Co., Spring Grove, Pa., *Chairman*

1. "Water Supplies for Papermaking, Past, Present and Future," by C. A. Snavely, Battelle Memorial Institute, Columbus, Ohio.
2. "Centrifuge Analysis for Suspended Solids in White Water," by E. A. Mason and R. R. Quincy, Mass. Inst. of Technology, Cambridge, Mass.
3. "Application of Ground Water Hydrology to the Development of Industrial Water Supplies," by Nicholas A. Rose, Consultant, Houston, Tex.
4. "Water Use Questionnaire Report," by Stephen Bergen, Conservation Foundation, New York, N. Y.
5. "Corrosion Prevention of White Water Treatment Equipment with Cathodic Protection," by F. E. Lefebvre, Electro Rust Proofing Co., Belleville, N. J.

9:15 a.m. Structural Fibrous Materials (Room A)

E. M. Jenkins, Johns-Manville Research Center, Manville, N. J., *Chairman*

1. "How Do TAPPI Standard Methods Fit the Needs of Hardboard Producers," by Wayne C. Lewis, Forest Products Laboratory, Madison, Wis.
2. "The Peculiarities of White Oak Hardwood Stock," by Sidney L. Schwartz, Forest Products Laboratory, Madison, Wis.
3. "The Evolution of Furnishes in Producing Insulating Board," by C. K. Textor and Lee Eberhardt, Bauer Bros. Co., Springfield, Ohio.
4. "Drainage-Time Testing of Insulating Board Pulp" (Panel Discussion).

9:15 a.m. Fundamental Research (East Ball Room)

Walter F. Holzer, Crown Zellerbach Corp., Camas, Wash., *Chairman*

1. "Reaction Products of Lignin Model Compounds and Sodium Hydrosulphide," by Thomas G. Zentner, Institute of Paper Chemistry, Appleton, Wis.
2. "Study of the Alkaline Nitrobenzene Oxidation of Chlorite Lignin," by Jack E. Jayne, Institute of Paper Chemistry, Appleton, Wis.
3. "Lignin-Carbohydrate Bond," by Elwin E. Harris, Forest Products Laboratory, Madison, Wis.
4. "Study of the Nature of the Absorption of Nitrogen, Butane, and Carbon Dioxide by Wood," by William R. Hasleton, Institute of Paper Chemistry.
5. "Dye Absorption on Wood Pulp. III. Effect of Pulping and Bleaching Variables on Specific Dye Absorption," by E. F. Thode, A. J. Chase, S. S. Majmudar, and D. R. MacKinnon, University of Maine, Orono, Me.
6. "Some Experiments on the Delignification of Wood," by B. L. Browning and L. O. Bublitz, Institute of Paper Chemistry.

9:15 a.m. Acid Pulping (West Ball Room)

E. H. Woodruff, Rayonier, Inc. Port Angeles, Wash., *Chairman*

1. "Converting to High Capacity Pulp Screens," by W. C. Stevens, A. P. Lynch, and P. W. Estes, International Paper Co., Chisholm, Me.
2. "Sulphur Distribution in the Sulphite Pulping of Western Hemlock," by Clarence Anderson, Rayonier, Inc., Shelton, Wash.
3. "Acid Pulping with Sodium Sulphate Liquor," by George A. Richter, Eastman Kodak Co., Rochester, N. Y.
4. "Miscellany on Ammonium Bisulphite," by Gordon A. Crowe, Spencer Chemical Co., Kansas City, Mo.
5. "Use of Spent Sulphite Liquor in Reconditioning Asphalt Road Surfaces," by Walter Sherman, Flambeau Div., Kansas City Star, Park Falls, Wis.
6. "Solids Determination of Pulp Residual Liquors," by J. H. Phillips, Babcock & Wilcox Co., Alliance, Ohio.
7. "Development of 65% Yield Sulphite for Newsprint Furnish," by Frank P. Silver and L. R. Beath, Price Brothers & Co., Ltd., Riverbend, Que.

9:15 a.m. Papermaking (Fourdrinier) Committee (Room E)

Round-Table Discussion—"Maintenance of Basis Weight" (Committee Only)

9:15 a.m. Wax Testing Committee (Room F)

2:00 p.m. Corrugated Containers (Grand Ball Room)

G. G. Johnston, Waldorf Paper Products Co., St. Paul, Minn., *Moderator*

Panel Meeting—"Chromium Plating-Roll Performance"

2:00 p.m. Papermaking (Cylinder) (West Ball Room)

James J. Harrison, Michigan Carton Co., Battle Creek, Mich., *Chairman*

1. "Test Method for the Determination of the Efficiency of Reject Removal," by G. B. Nicholson, Black-Clawson—Shartle-Dilts, Fulton, N. Y.
2. "New Developments and Application of Automatic and Remote Controls as Applied to Paper Manufacture," by J. H. Pearson, Shartle Bros. Machine Co., Middletown, Ohio.
3. "The Mechanical Properties of Paper II," by Geoffrey Broughton, University of Rochester, Rochester, N. Y.

2:00 p.m. Pulp Purification and Chemical Engineering (East Ball Room)

R. La McEwen, Buffalo Electro-Chemical Co., Buffalo, N. Y., and J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga., *Chairmen*

1. "Explosives in Chlorine Absorptive Systems," by E. A. Mason, W. C. Bauer, and R. R. Quincy, Mass. Inst. of Technology, Cambridge, Mass.
2. "On the Mechanism of Sulphur Dioxide Absorption in Aqueous Media," by R. P. Whitney, S. T. Han, and J. Lawler Davis, Institute of Paper Chemistry, Appleton, Wis.
3. "The Evaporation of Ammonia-Base Waste Sulphite Liquor and Recovery of Ammonia," by L. C. Jenness,

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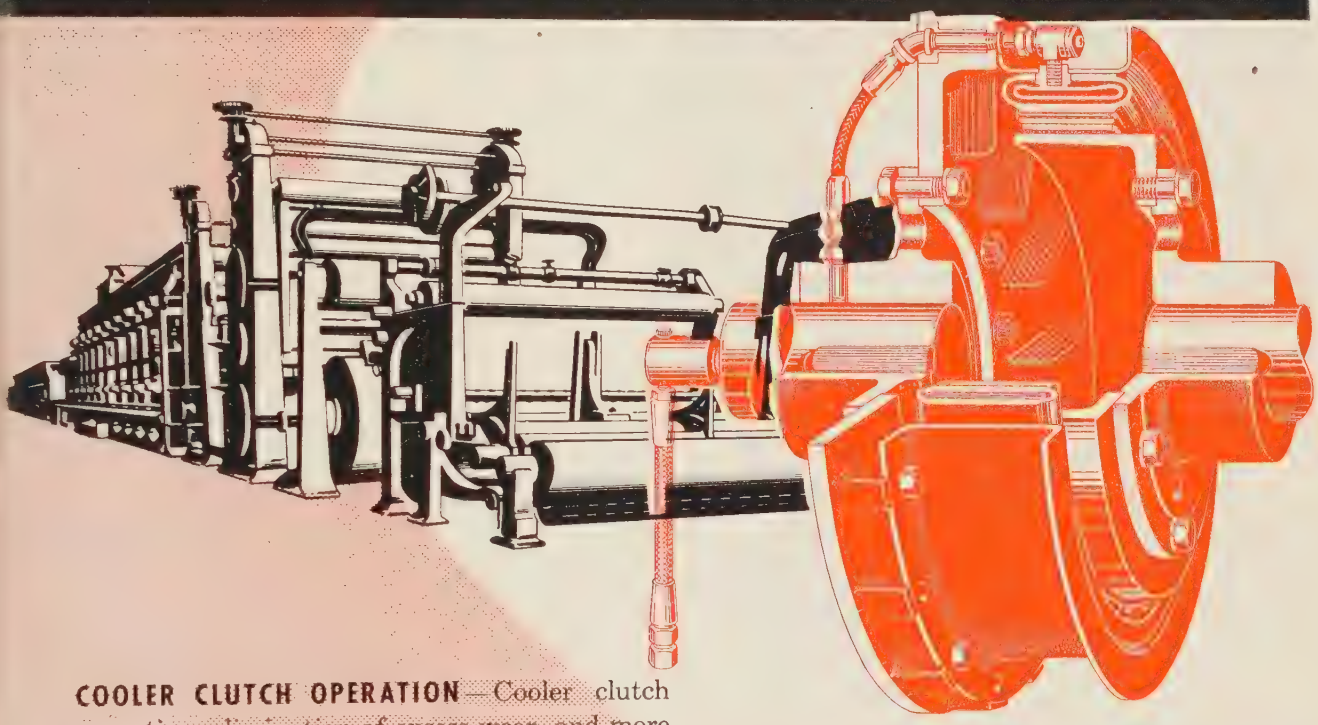

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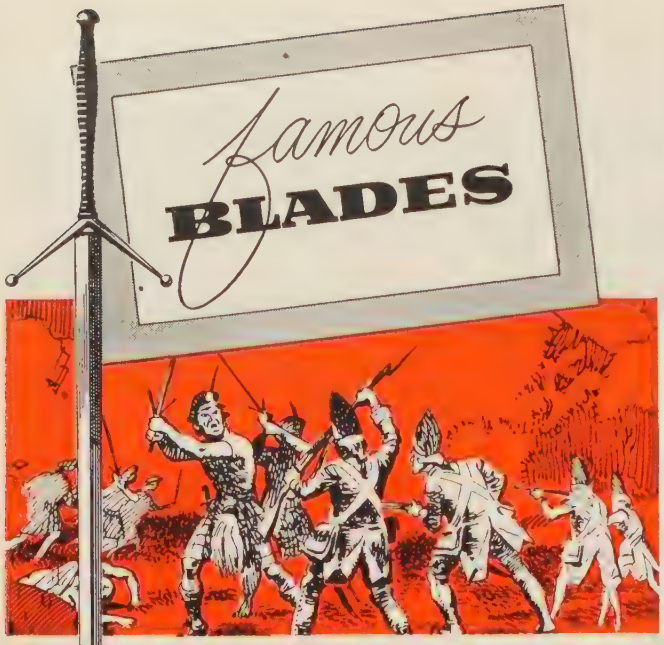

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2:00 p.m. ***Statistics (Room B-C)***

J. F. Langmaid, Jr., S. D. Warren Co., Cumberland Mills, Me.

"Basic Principles on the Use of Control Charts in the Pulp and Paper Industry," C. A. Bicking, Discussion Leader.

2:00 p.m. ***Structural Fibrous Materials Committee (Room F)***

2:00 p.m. ***Container Evaluation and Development Committee (Room G)***

2:00 p.m. ***Papermaking (Fourdrinier) Committee (Room E)***

Round-Table Discussion—"Determination of Fourdrinier Machine Efficiency" (Committee Only)

2:00 p.m. ***Wax Testing Committee (Room A)***

WEDNESDAY, FEBRUARY 18, 1953

9:15 a.m. ***Corrugated Containers (Grand Ball Room)***

Keith Max, Robert Gair Co., Uncasville, Conn., *Moderator*

Panel Discussion—"Résumé of the Waste Questionnaire"

9:15 a.m. ***Semichemical Pulping (West Ball Room)***

J. N. McGovern, Forest Products Laboratory, Madison, Wis., *Chairman*

1. "Experiments on the Kinetics of Sodium Sulphite Semichemical Pulping," by L. K. Doraiswany and J. N. McGovern, Forest Products Laboratory, Madison, Wis.
2. "Semichemical Pulp from Mixed Eastern Hardwoods for Bond Paper," by J. N. McGovern and F. A. Simmonds, Forest Products Laboratory, Madison, Wis.
3. "High Yield Pulping—An Estimate of the Future," by C. W. Converse, Sprout, Waldron & Co., Muncy, Pa.
4. "Semichemical Pulping of Southern Red Oak," by Donald J. MacLaurin, Institute of Paper Chemistry, Appleton, Wis.
5. "Bleached Semichemical Pulp from Birch and Maple," by Donald J. MacLaurin, Institute of Paper Chemistry, Appleton, Wis.
6. "Present Methods of Concentrating Semichemical Spent Liquor," by Opferkuch and Moggio, National Council for Stream Improvement, New York, N. Y.

9:15 a.m. ***Paper Deinking (Room A)***

J. J. Forsythe, Jr., International Paper Co., Niagara Falls, N. Y., *Chairman*

Symposium—"Waste Paper Quality"

9:15 a.m. ***Fundamental Research (East Ball Room)***

Symposium "Management of Research"

1. "The Organization of a Research Department," by Henry N. Stephens, Minnesota Mining & Mfg. Co., St. Paul, Minn.
2. "The Scope of Research in the Pulp and Paper Industry," by F. H. Frost, S. D. Warren Co., Cumberland Mills, Me.
3. "The Stimulation of Research," by Wendell W. Moyer, Crown Zellerbach Corp., Camas, Wash.
4. "Manpower for Research," by M. H. Trytten, Office of Scientific Personnel, National Research Council, Washington, D. C.
5. "Selling Research to Labor and Management," by M. O. Schur, Ecusta Paper Co., Pisgah Forest, N. C.

9:15 a.m. ***Preparation of Papermaking Materials (Room B-C)***

F. S. Klein, Byron Weston Co., Dalton, Mass., *Chairman*

1. "Surface Properties of Rosin Size Precipitate. I. Factors Affecting Formation of Resin-Aluminum Sulphate Com-

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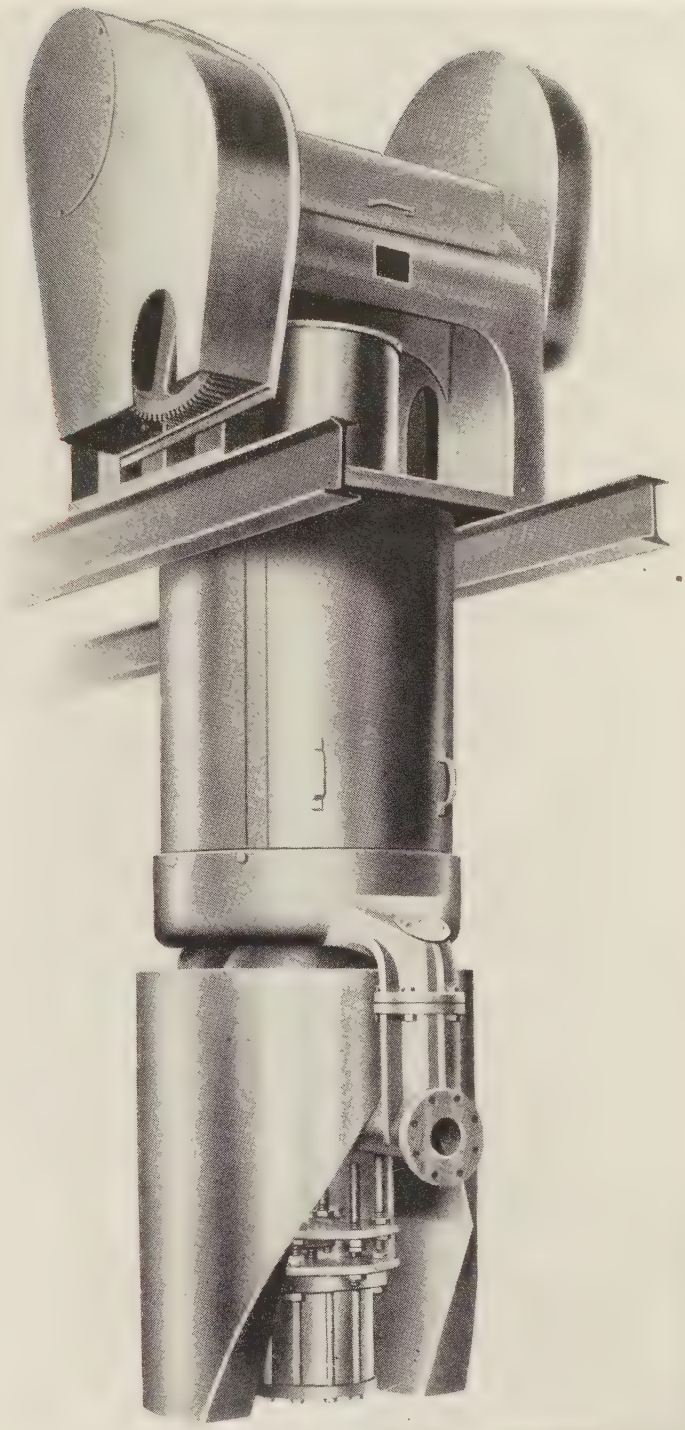

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plex," by E. F. Thode, J. F. Gorham, and R. H. Atwood, University of Maine, Orono, Me.
2. "Surface Properties of Rosin Size Percipitate. II. Effect of Foreign Ions on the Electrophoretic Mobility of Rosin-Aluminum Sulphate Complex," by J. F. Gorham and E. F. Thode, University of Maine, Orono, Me.
3. "The Removal of Dirt and Gases from Pulp Stock Suspensions," by Horace Freeman and J. D. Boadway, Consolidated Paper Co., Ltd., Three Rivers, P. Q.
4. "Use of Aluminum Chloride in Melamine Treated Papers," by Eastman Kodak Co., Rochester, N. Y.
5. "Mannangalactan Gums: The Mechanism of Retention by Paper Fibers," by N. S. Gruenhut, Stein, Hall & Co., New York, N. Y.

9:00 a.m. Papermaking (Tissue Subcommittee) (Room E)

9:00 a.m Wax Testing Committee (Room G)

2:00 p.m. Corrugated Containers (Grand Ball Room)

W. W. Marteny, National Container Corp., Tomahawk, Wis., *Moderator*

Panel Discussion—"The Glued Lap Box"

1. "Adhesives and Their Application in the Manufacture of Glued Lap-Joint Containers on the Various Machines," by F. R. Di Franco, National Starch Products, Inc., Plainfield, N. J.
2. "Glued Lapped Joints on Fiber Containers," by Alfred W. Hoffman, Container Laboratories, New York, N. Y.
3. "Machinery to Manufacture Glued Lap Joint Type Containers," by Ray A. Thompson, Samuel M. Langston Co., Camden, N. J.

2:00 p.m. Fundamental Research (East Ball Room)

Harry F. Lewis, *Moderator*

Question and Answer Panel—"Problems in the Operation of a Pulp and Paper Research Department"

Note: Questions should be sent in advance of the meeting to Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis., or given to him at the session.

2:00 p.m. Paper Deinking (Room A)

J. J. Forsythe, Jr., International Paper Co., Niagara Falls, N. Y., *Chairman*

Symposium "Deinking Problems"

2:00 p.m. Chemical Products and Alkaline Pulping (West Ball Room)

Arthur Pollak, Consultant, New York, N. Y., and R. R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala.

1. "Tall Oil Esters in Varnishes," by Paul R. Wiley, West Virginia Pulp & Paper Co., Charleston, S. C.

2:00 p.m. Packaging Materials Testing and Microbiological (Room B-C)

L. E. Simerl and R. F. DeLong, Marathon Corp., Rothschild, Wis., *Chairmen*

1. "Development of Design Data for Small Folding Cartons," by R. S. Williams, Marathon Corp., Menasha, Wis.
2. "A Bacterium with a High Resistance to Organomercurials *Achromobacter guttatum*," by John W. Appling and Stanley J. Buckman, Buckman Laboratories, Memphis, Tenn.
3. "Report of Subcommittee on Mildew Resistance," by F. B. Shema, Institute of Paper Chemistry, Appleton, Wis.
4. Discussion of Methods of Testing for Mildew Resistance.

2:00 p.m. Statistics (South Room)

2:00 p.m. ASTM D-6–D-9 Committees (Room G)

2:00 p.m. Wax Testing Committee (Room F)

THURSDAY, FEBRUARY 19, 1953

9:00 a.m. Digester Corrosion (Room A)

Nicholas Shoumatoff, West Virginia Pulp & Paper Co., New York, N. Y., *Chairman*

1. Introduction by H. O. Teeple, International Nickel Co., New York, N. Y.
2. "Uneven Corrosion in Alkaline Pulping Digesters—A Major Cause and Possible Cures," by F. W. Flynn, Crown Zellerbach Corp., Camas, Wash., and F. B. Snyder and F. H. Richter, Babcock & Wilcox Co., New York, N. Y.
3. "Some Observations on Causes and Prevention of Kraft Digester Corrosion," by E. W. Hopper, Crucible Steel Co. of America, Pittsburgh, Pa.
4. "Experiences with Field Applied Inconel Digester Linings," by S. J. Baisch, Thilmany Pulp & Paper Co., Kaukauna, Wis.
5. "Pressure Vessel Steel Specifications and Related Steelmaking Processes," by H. F. Peters, Lukens Steel Co., Coatesville, Pa.
6. "Hastelloy F—A New Corrosion Resistant Alloy for Lined Digesters," by M. O. Scheill, A. O. Smith Corp., Milwaukee, Wis.

9:00 a.m. Chemical Methods and Optical Properties (Room B-C)

A. S. O'Brien, Eastman Kodak Co., Rochester, N. Y., and H. E. Obermanns, Hammermill Paper Co., Erie, Pa., *Chairmen*

1. "Solids Determination of Pulp Residual Liquors," by Frank E. Hutton, Babcock & Wilcox Co., New York, N. Y.
2. "Chain Length Distribution of Cellulose," by Geoffrey Broughton, University of Rochester, Rochester, N. Y.
3. "Variable Shear Viscometers for Cellulose Intrinsic Viscosity Determination," by H. F. Wetzel, J. H. Eliott, and A. F. Martin, Hercules Powder Co., Wilmington, Del.
4. "Measurement of Gloss of Waxed Papers," by P. J. Gianacakes and F. H. McLaren, Standard Oil Co. (Ind.), Whiting, Ind.
5. "Fundamental Dimensions of Appearance Quantities," by R. S. Hunter, Hunter Associates, Falls Church, Va.

9:00 a.m. Papermaking (Fourdrinier) (West Ball Room)

N. R. Phillips, Champion Paper & Fibre Co., Canton, N. C., *Chairman*

1. "The Deculator on a Kraft Paper Machine," by A. W. Duskin and W. B. Jenkins, Crossett Paper Mills, Crossett, Ark.
2. "Automatic Transfer Equipment," by J. E. Goodwillie, Beloit Iron Works, Beloit, Wis.
3. "A New Principle for Consistency Control for Pulp and Paper Stocks in All Ranges Using Resotronic Regulator," by Norman S. Grant, Spruce Falls Power & Paper Co., Kapuskasing, Ont.
4. "The Liquid Ring Compressor—Some Thermodynamic Characteristics," by Harold E. Adams, Nash Engineering Co., South Norwalk, Conn.
5. "The Organization of a Small Engineering Laboratory," by A. W. Pomper, John Waldron Corp., New Brunswick, N. J.

1:00 p.m. Annual Luncheon (Grand Ball Room)

Kenneth P. Geohegan, *Chairman*

1. Introduction of Guests.
2. Address—"The Progress of Research in the Pulp and Paper Industry," by Allen Abrams, Vice-President in Charge of Research, Marathon Corp., Rothschild, Wis.
3. TAPPI Medal Presentation to Roger C. Griffin by James d'A. Clark.
4. Adjournment by President Elect.

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Protective Packaging with Aluminum Foil

W. J. FAYMONVILLE

THERE are many applications for aluminum foil packaging which have not been investigated. When considering either a standard or a new use for foil the packaging technician may not find adequate reference data from which to proceed. This article is intended as a reference guide for aluminum foil packaging material, data, techniques, and end uses.

There is no question about the sales appeal and merchandising advantages of printed aluminum foil. However, because of the relative cost of such packaging materials, sometimes products really needing more protection than they are getting are not using aluminum foil.

Perhaps it is because it is not known just how aluminum foil protection can be put into use at low cost. Whatever the reason may be, the broad field of protective packaging application through the use of aluminum foil unprinted, and hidden away in the package has not been explored adequately.

Beginning with principles which make aluminum foil a potentially effective packaging material, examine how an aluminum foil product can be selected to enhance a package as well as be accommodated by packaging machinery.

PACKAGING MATERIAL EVALUATION

A common basis for the evaluation of protective material is its moisture vapor transmission or transfer rating (MVT). Other properties such as greaseproofness, opacity, selective gas permeability, toxicity, stability, etc., assume varying degrees of importance, depending upon the specific packaging application. Moisture vapor transfer takes on useful significance when comparing the rating of various materials against each other.

MVT is assigned units of rate of transfer of moisture vapor through a definite area of material under specific conditions. It is the number of grams of moisture vapor which will penetrate 100 sq. in. of material in 24 hr. in an atmosphere of from 90 to 95% relative humidity at 100°F.*

Moisture vapor transfer is not a unit by which a finished package is evaluated. It is an estimate of the moisture vapor permeability of a material. A finished package may have folds, seams, and seals which may be more vulnerable to the admission of moisture vapor than the material itself.

The surface area of a package, not the volume, is correlated to the relative protection to be expected between one material and another for the same surface area. The effect of seals at seams is a function of the packaging material selected. The ratio between volume and seam length is equally as important as the ratio between volume and surface area (Fig. 3).

To compare packages from a standpoint of product behavior, each manufacturer must establish his own test procedure for evaluation of package performance.

FOIL PRODUCTS AND CHARACTERISTICS

Theoretically, the thinnest sheet of metal imaginable still is a perfect barrier against moisture vapor, light, odor, gaseous products, dust, dirt, grease, and bacterial contamination.

Because of its unusual ductility, aluminum can be rolled into thicknesses of 0.00025 in. or less. Aluminum less than 0.006 in. in thickness is called foil. The purity of the metal used for this extremely thin application is 99.35% minimum aluminum content.

Opinions and commitments will vary, but it is generally agreed that aluminum foil has zero MVT at a thickness between 0.0015 and 0.002 in.† Below this thickness range, the MVT is shown to rise gradually (curve 4, Fig. 1).

The reason for the rise in MVT as the gage decreases is the occurrence of small perforations in the foil sheet. These penetrations commonly are referred to as "pin holes" and their effect is in proportion to their presence in number.

To be acceptable as a packaging material, aluminum foil must perform as well or better than other materials on existing packaging machinery. As a rule, it is not necessary to provide infinite shelf-life protection for the majority of products going into a consumer unit package. Usually, a compromise is sought, the degree of increased shelf-life being modulated by sensible cost combinations of aluminum foil laminated to a "carrier"; another material, usually a paper or film.

The selection of a carrier for lamination to the foil will be governed both by the requirements of the packaging machinery to be used, as well as additional qualities, mentioned before, necessary for use in combination with the product to be packaged.

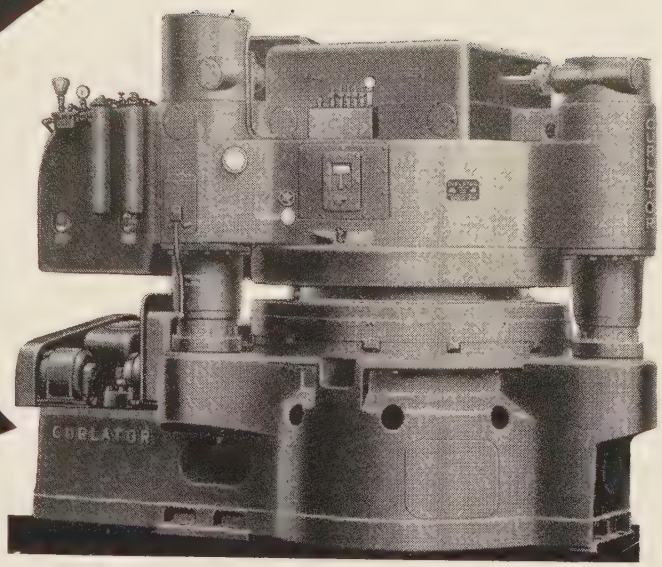
Physical characteristics of laminated foil materials are tested by methods used for testing plain paper. Except for stiffness and bursting strength, the physical constants of laminated aluminum foil are dominated by either the carrier or the foil, depending upon the gage of the foil and the qualities of the carrier. In the lighter gages of aluminum foil (0.0005 in. and less), the mechanical characteristics of the laminated product

W. J. FAYMONVILLE, Chief Packaging Engineer, Products and Applications, Reynolds Metals Co., Louisville, Ky.

* Using ASTM approved cabinet.

† MVT ratings seldom are listed as zero, but more commonly as "less than 0.05 gram." The reason for this is that manual errors in technique while making the determination can exceed 0.05 gram. MVT usually is given as a spread or range, less than 0.05, 0.05 to 0.10, 0.10 to 0.15 gram, etc.

ANOTHER BIG REASON for installing A CURLATOR



14 LEADING MILLS ARE NOW CURLATING THEIR PULP

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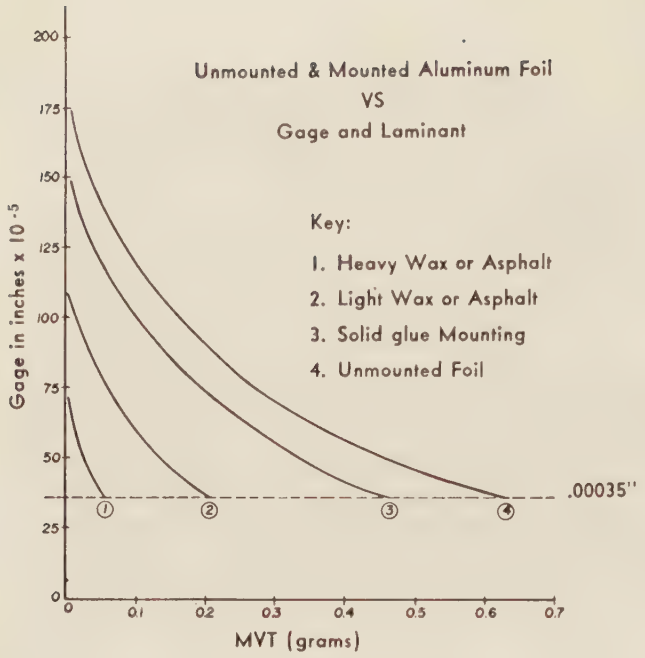

Fig. 1. Theoretical comparative MVT ratings

combination are influenced by the nature of the carrier itself.

Conversely, the MVT rating of a laminated aluminum foil is influenced little, if any, by the carrier. The MVT of the lamination is affected very strongly by the type and amount of laminating adhesive used. Foil, even very thin foil, has far better MVT characteristics than either the materials used most commonly for lamination to the foil or the laminant used.

Examination of Fig. 1 illustrates the influence of the laminating agent on the MVT as well as the result of the use of varying thicknesses of aluminum foil.‡ The principal deviation in the set of curves in Fig. 1 occur either when there is a change in the gage of the foil, or when the type or amount of the laminating agent is varied. The carrier is depicted as having little or no influence on the MVT.§

A study of Fig. 2 discloses that the MVT can be controlled by varying either the laminating agent or the gage of the metal. Figure 2 is an amplification of the general principles and product tendencies illustrated by curves 1 and 2 of Fig. 1.

The important thing to note in both sets of curves is the significant role assumed by the wax laminating agent permitting the use of flexible foil-carrier combination and maintaining a low MVT rating with extremely thin aluminum foil.

As cited earlier, the effect of the MVT rating of the packaging material on the package performance is directly proportional to the surface area of the package. The effect of folds and seams of a package is of equal importance, but usually is denoted by a performance curve (Fig. 3) rather than by a physical unit.

The curves given in Fig. 3 illustrate the theoretical relationship between expected package performance with respect to surface area and total seam length for a given package of fixed volume and using the same foil packaging material. Note that the relative performance of all four packages is depicted as being reasonably the same. This is true of aluminum foil materials, but may not be true for other packaging media. Curves 3, 3a, and 4 illustrate expected relative performance deviation for nonmetallic packaging materials.

When studying prospective use of foil packaging materials the efficiency of the seams is the most important consideration. The MVT is so superior to that of nonmetallic media that the gain or loss through the surface of the package is very slight in respect to the possible opening at a seam. Foil packaging materials are designed to produce a seal of maximum efficiency at the seams. However, a seam usually is more vulnerable than the surface or foil membrane. Therefore, special attention should be directed toward efficient seals at the seams. It this is done, package performance can be expected to follow the general trends shown in curves 1, 2, and 3 of Fig. 3. (Curve 4 representing the cube is theoretical, as the seam efficiency of square end is closer to the performance of curve 4a.)

A comparison between volume, surface area, and total seam area illustrates the greater efficiency of foil packaging over that to be expected through the use of other materials. Note from the following data that the expected performance is very much the same regardless of the seam length to surface area ratio when foil is used.

Fig. 3 package	*4*	*1*	*2*	*3*
Volume, sq. in.	56	56	55	56
Surface area, sq. in.	88.5	100	108	145
Total seams, in.	11.5	15	16.75	21.25
Seams/surface	1/7.7	1/6.6	1/6.5	1/7.9
Volume/surface	1/1.6	1/1.8	1/2	1/2.6
Seam/volume	1/4.9	1/3.75	1/3.3	1/2.6

1. 56 cu. in. Volume Seams-15 in. | 2. 55 cu. in. Volume Seams-16¾ in. | 3. 56 cu. in. Volume Seams-21¼ in. | 4. 56 cu. in. Volume Seams-11½ in.

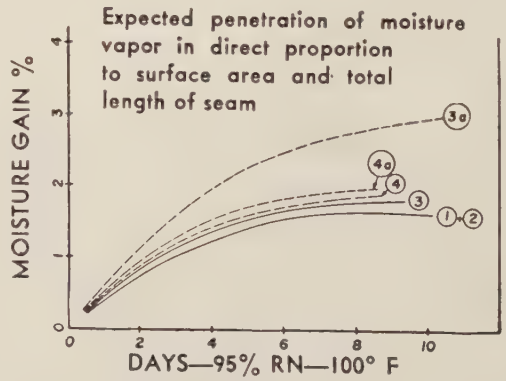

Fig. 2. Theoretical comparison of packages having nearly equal volume

‡ The curves used for Fig. 1 are only approximations, and are given to illustrate general tendencies in characteristics of aluminum foil products.

§ Do not confuse the effect of the carrier on the MVT with the effect on the package performance as a consequence of seals and seams to be discussed later in the article. Also see notes on films.

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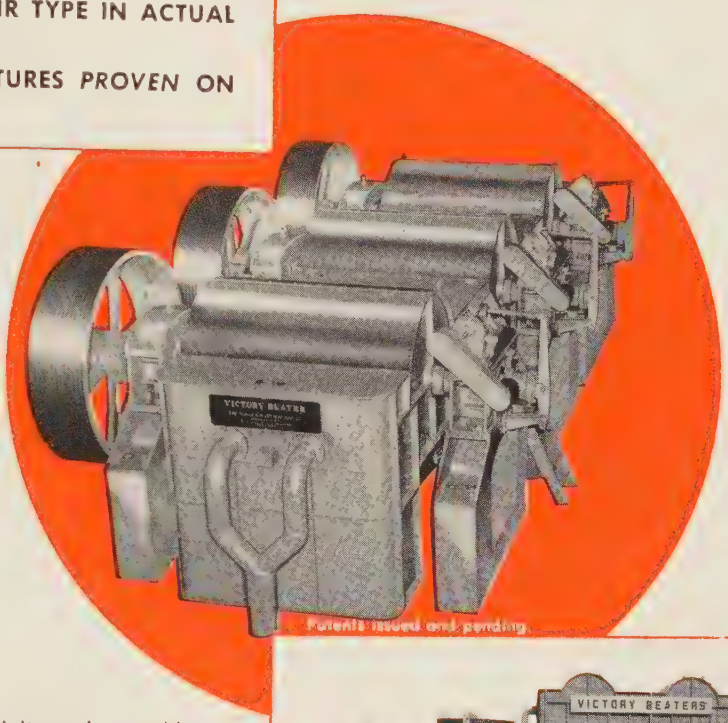

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PROVEN! Flexibility of design and completely automatic controls allow "tailored to your plant" installation. Can be made in stainless steel. Many types of stock chests in use on other floors, above or below Victory Beaters. Motors can be mounted at top to conserve floor space if desired. Shipped complete on flatcars, ready to install.

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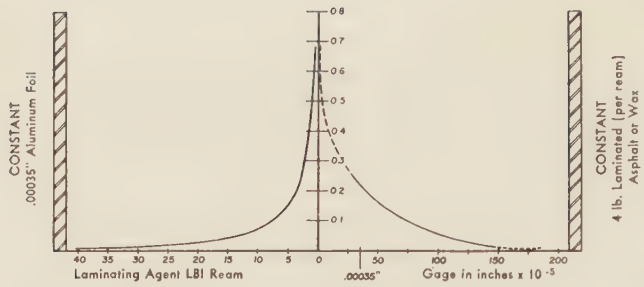

Fig. 3. Comparison of general effect of foil gage and laminating agent on MVT

Aluminum foil, to be useful as a packaging material, usually is laminated to paper or film. In the third column of Table I, a number of foil materials are listed. These products are both plain (unmounted) and laminated, and represent materials in use today. To estimate the MVT of these materials, refer to Fig. 1. The remainder of Table I will be explained later on.

PACKAGE FORMS AND MATERIAL DIFFERENCES

The foregoing data have indicated how well an aluminum product might be expected to perform as a moisture vapor barrier. The next step is to select a combination of foil, laminating agent, and carrier which will both satisfy the requirements of cost and protection as well as accommodate the product to be packaged, and operate on the packaging equipment. Once the package is "made up," relative performance of various specifications and package forms can be studied. Package performance curves, similar to those given in Fig. 3, can be plotted and evaluated.

It is in this stage of the packaging study that the effect of seams and seals, compatibility of carrier or foil in intimate contact with the product, and probable shelf-life performance can be recorded.

Acceptability of carrier to product packaged is too specific for discussion in this article. The answers to the problems of the choice of paper or film to laminate, or exact formulation to be used for a coating will depend upon the specific packaging instance, and the individual requirements.

The end-use listing of Table II is cross-referenced with Table I, and should serve as a guide to the proper selection of foil specifications relative to protection to be expected, efficiency of seams, and probable relative cost for any one packaging group.

It will be noted that there are four general forms given for unit packaging at the consumer level: the bag, the liner, the wrap (with and without a carton), and the label. Illustrative Figs. 5 through 7 show the general outline form of these styles, as well as examples of present consumer packages using these forms.

The selection of one foil product in preference to another within any one group depends upon a number of items. Relative protection (exclusive of MVT) depends largely upon the efficiency of seals and the vulnerability of the exposed edges of the seams (wicking). The cross sections of various foil materials shown in Table I indicate the usual method of making seals at the seam of a package. Figure 4 illustrates the probable entrance or escape route of moisture, aromatic spirits, and grease.

Assuming that a seal has been well made, note the possible path of loss or gain of undesirable elements via the sealing medium, wicking action of paper edge, etc. Keep in mind that this comparison is between foil materials, and not between foil and nonmetallic packaging media.

It is not possible always to employ the most highly effective foil material for any one package type. Considerations of cost or packaging machinery requirements will influence the selection to the largest degree. On the other hand, a misapplication of an aluminum foil specification results in a misunderstanding of the economy and saving possible through the use of foil.

The protection to be gained from any foil material for any end use can be no better than mechanical application or technique used to apply the material. The preference selections of Table II were listed with this in mind. The usual packaging machinery em-

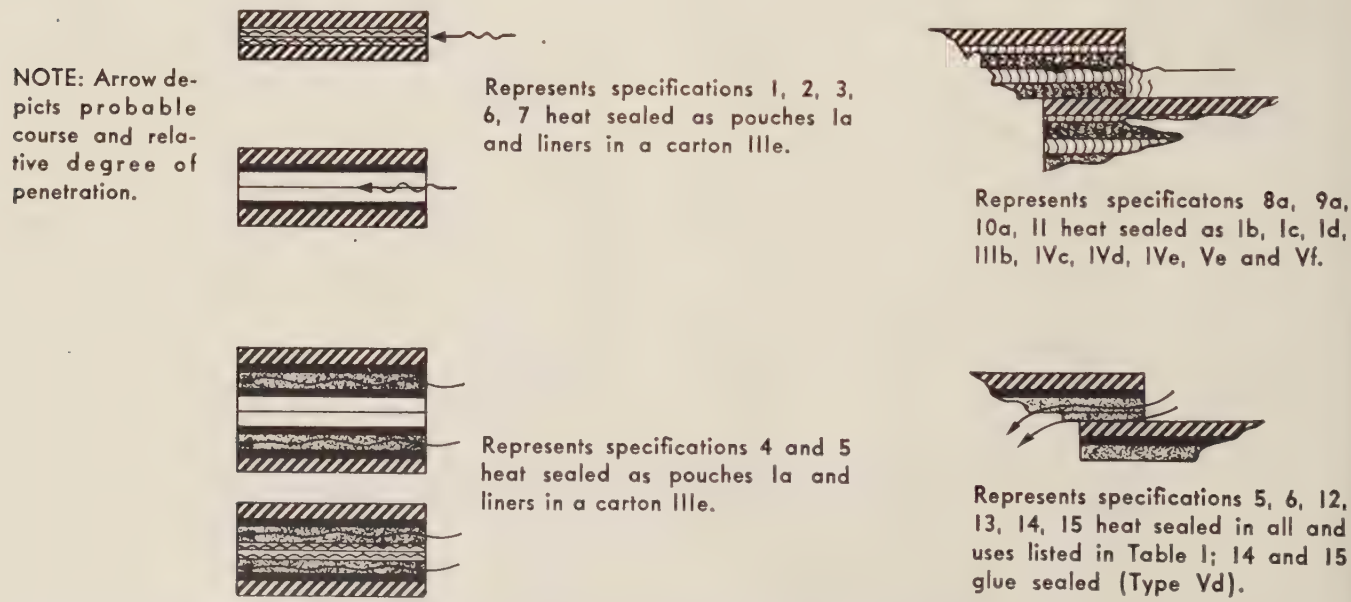
NOTE: Arrow depicts probable course and relative degree of penetration.
Represents specifications 1, 2, 3, 6, 7 heat sealed as pouches Ia and liners in a carton IIIe.
Represents specificatons 8a, 9a, 10a, II heat sealed as Ib, Ic, Id, IIIb, IVc, IVd, IVe, Ve and Vf.
Represents specifications 4 and 5 heat sealed as pouches Ia and liners in a carton IIIe.
Represents specifications 5, 6, 12, 13, 14, 15 heat sealed in all and uses listed in Table I; 14 and 15 glue sealed (Type Vd).

Fig. 4. Possible avenue of escape or entry of moisture through seams or seals (refer to Tables I and II for specification numbers and end use)

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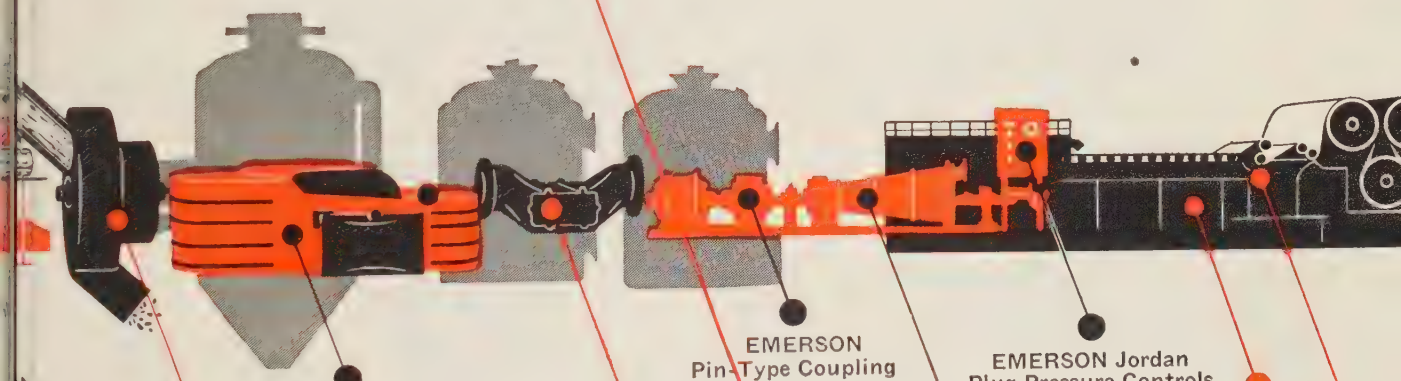

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Table I. Components, Cross Sections, and End Use of Various Packaging Materials

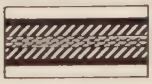
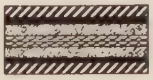
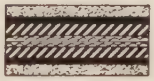
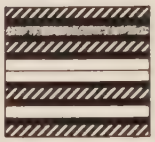
NO.	COMPONENTS	SECTION	SEAMS OR SEALS	USE—SEE TABLE II
1.	.0005" to .003" Foil Heat seal coating			Ia
2.	.0005" to .002" Foil Adhesive Heat sealing films			Ia IIIe
3.	Cellulose acetate Adhesive .001" to .002" Foil Heat seal coating			Ia
4.	.00035" to .001" Foil Adhesive Paper Adhesive Heat seating films			Ia IIIe
5.	.0035" to .001" Foil Adhesive Paper Heat seal coating			Ia IIIe Vd
6.	Paper Adhesive .00035" to .001" Foil Heat seal coating			Ia IIIe Vd
7a.	.00035" to .0008" Foil Adhesive Paper Adhesive .00035" to .0008" Foil Heat seal coating			Ia
7b.	Same as above except Heat sealing films			Ia
8.	.00035" to .0005" Foil Wax Porous tissue			IIIa, IIIc IVc, IVe (plus 9 or 10) Va, Vb, Ve
9.	.00035" to .0005" Foil Wax Tissue Wax Porous tissue			Ib, Ic, Id IIIa, IIIb, IIIc, IVc, IVe (plus 8, 9, or 10) Va, Vb, Ve
10.	.00035" to .0005" Foil Glue Tissue Wax Porous tissue			IIIb, IIIc IVa, IVb, IVc, IVe (plus 8 or 9) Va, Vb, Ve
11.	Printed waxed paper, transparant or opaque plus Specification 8 or 9			IIIb IVd Va, Vf
12.	.00035" to .0005" Foil Adhesive Paper Non-blocking thermoplastic coating			IVc Vd
13.	Registered heat seal .00035" to .0005" Foil Adhesive Paper Registered heat seal		 	Ib Vc
14.	Paper Glue or wax .00035" to .0005" Foil Glue or wax Paper			Ic, Id IIIc Ic, Id IIa, IIb IIIa, IIIc, IIId IVa, IVb Va, Vb, Vc VIa, VIb, VIe
15.	.00035" to .0005" Foil Glue or wax Paper		Can be glue or registered stencil sealed, or may not be sealed at all	

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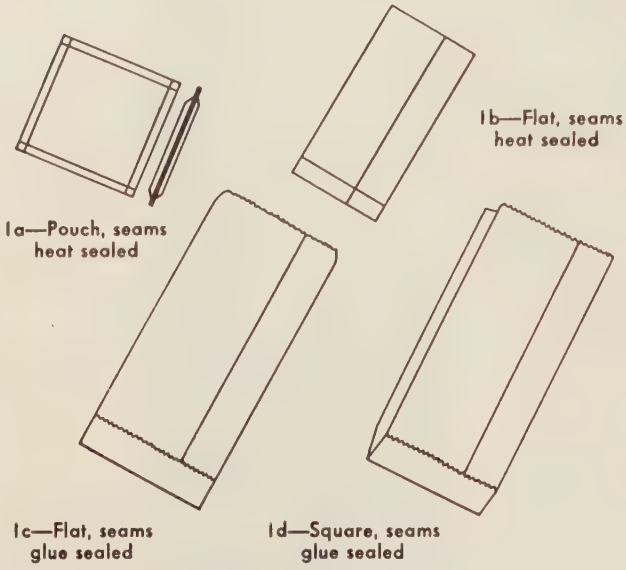
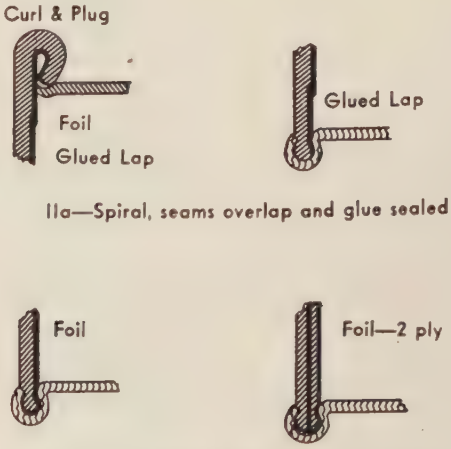
Table II. Some Package Forms Incorporating Use of Aluminum Foil

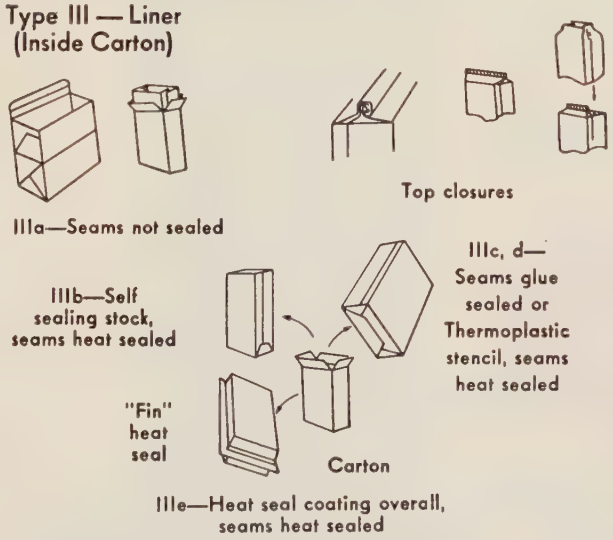
Type I — Bags



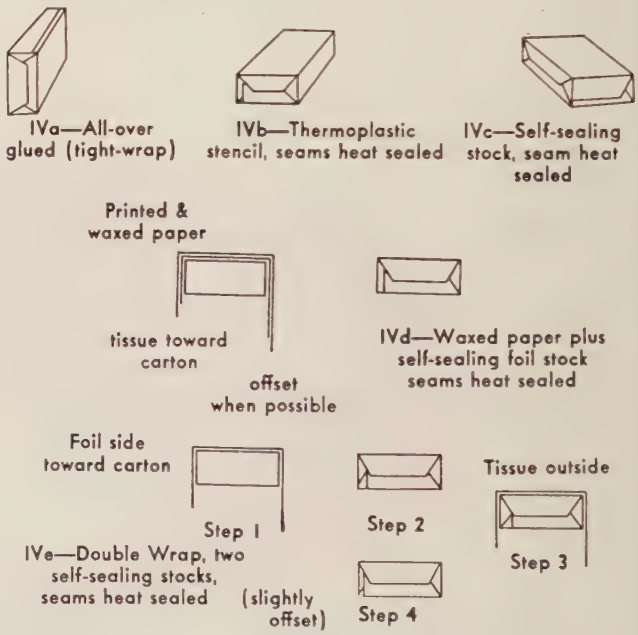
Type II — Liner (In a fibre cannister)



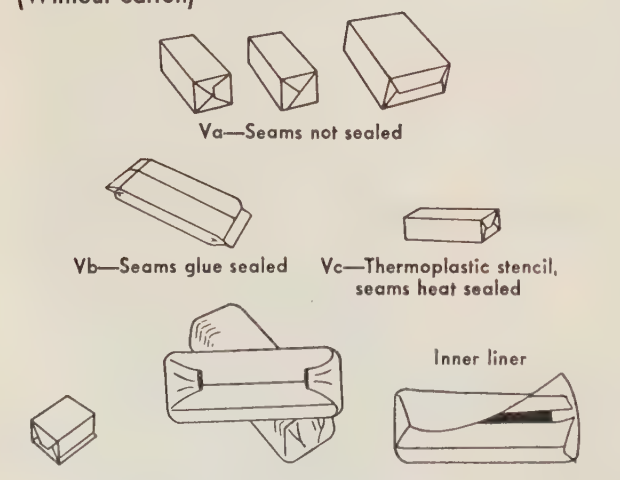
Type III — Liner (Inside Carton)


Top closures
IIIa—Seams not sealed
IIIb—Self sealing stock, seams heat sealed
IIIc, d—Seams glue sealed or Thermoplastic stencil, seams heat sealed
"Fin" heat seal
Carton
IIIe—Heat seal coating overall, seams heat sealed

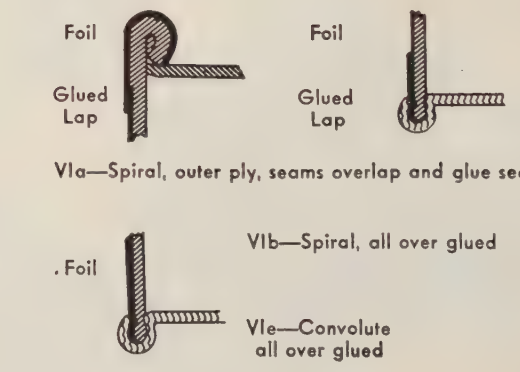
Type IV — Wrap (over carton)



Type V — Wrap (Without carton)


Va—Seams not sealed
Vb—Seams glue sealed
Vc—Thermoplastic stencil, seams heat sealed
Inner liner
Vd—Heat seal coating over all, seams heat sealed
Ve—Self-sealing stock, seams heat sealed
Vf—Waxed paper plus self-sealing foil stock, seams heat sealed

Type VI — Label (On Fibre Cannister)



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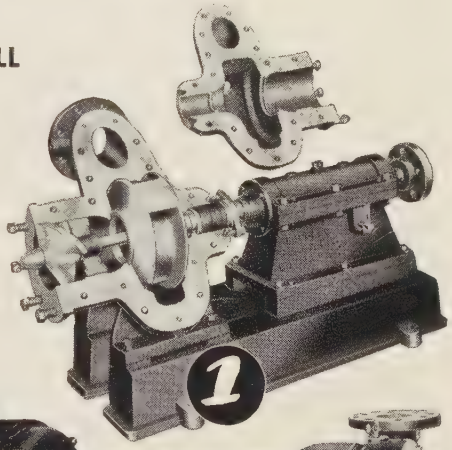

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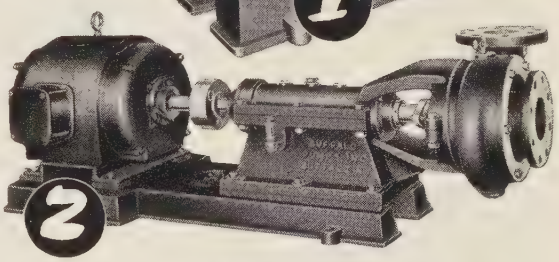

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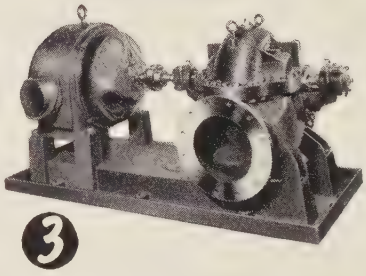

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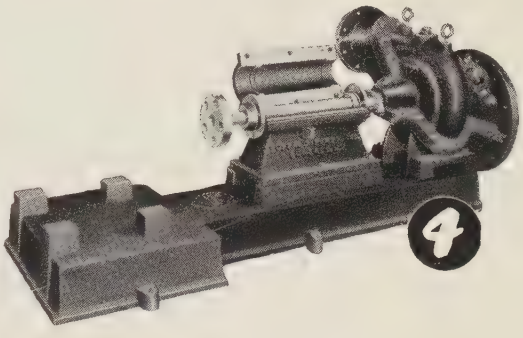

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ployed to produce any package style or form was considered carefully prior to any indication of choice of specification. There are many more variations possible than are listed in Tables I or II. Those specifications given represent past and present satisfactory applications.

Ascertain the standards of protection and appearance for the product. Calculate how much could be allotted for packaging material costs to achieve these standards. Select an aluminum foil material from Table II, and conduct comparative testing with other materials.

Fig. 5

Additional clarification of the data set forth herein may be necessary in some instances. The following contains a group of notations and explanations covering the reasons for the selections given in Table II.

SPECIFICATIONS (TABLE I)

Specifications nos. 1 through 7 are designed primarily for use as pouches (type Ia), employing a flat, back-to-back seal. Liner in a carton type IIIe (specs. 4, 5, 6) essentially is a pouch.

The reason for the variety of pouch specifications is the variety of end-use requirements, and equipment used to manufacture, form, fill, and seal the package. In general, ease in opening and filling is obtained through the use of a film somewhere in the specification. Also, the more flexible the stock, the less tendency toward "darts" or "fishtails" at the seams.

In specification no. 3, the film carries the printing, the paper in no. 6, and the foil in all the rest through no 7. The adhesive between film and foil can be tinted.

The use of film as a sealing medium permits the packaging of semiliquids, creams, and products requiring selective gas permeability (nitrogen gas packaging, for instance).

The use of specification no. 7 permits maximum flexibility along with maximum protection.

Embossing can be employed to obtain still greater flexibility.

Specifications nos. 8 through 11 are wrap (with or without carton) types IV and V and liner in carton materials type III.

The presence of the porous tissue liner sheet permits the strike-through of wax to make the seal and provides a dry tissue next to the product. This prevents blocking in rolls and guards against "thermal creep" occurring in specification no. 12.

If greasy products are to be wrapped using nos. 8 through 11, a special wax formulation will be necessary to prevent wicking and delamination.

The heat-sealing technique for specifications nos. 8 through 11 is heat and mild pressure followed by a holding action to set the wax (not refrigeration unless very high speeds are employed).

Any metal-to-metal surfaces not sealed (as in end folds or bottom folds) *are not open channels.* The wax bleeds through and blocks off possible entry. Inexperienced observers request the application of a heat-sealing coating in the metal surface. The only purpose such a coating serves is insurance against the end folds falling open. This will not be a problem until the piece or carton end approaches a square, in which case a coating is used to hold the seams together. A carton or piece wrapping machine is not equipped to effect a moisture-tight seal. This is pouch sealing technique.

The waxed paper in specification no. 11 is used to carry the printing for types IVd and Vf, and to prevent mandrel blocking in type IIIb. A sulphite is recommended rather than a glassine. In types IVd and Vf, the foil shines through if a transparent sulphite is used. A straight paraffin wax should be used for type IIIb applications.

Specification 12 is satisfactory when applied over a carton, or over a product having an inner liner; the coating may "creep" when heat is applied, and offset into the product (Vd).

Specification 13 is used quite frequently in place of a glue seal for bags and candy bar goods wraps.

Specification 14 solves a sealing or gluing problem in instances of equipment inflexibility.

Specification 15 is an all-purpose foil material used when protection is not the prime objective, or as types II and VI canister applications.

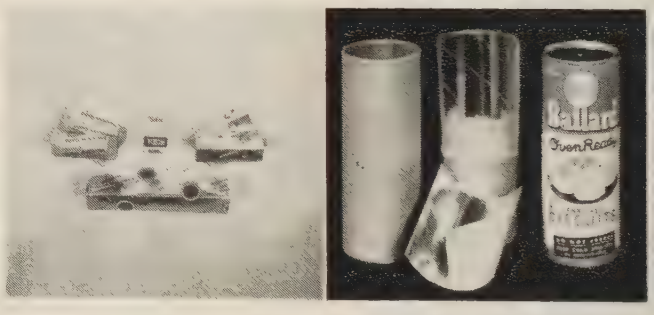

Fig. 6

Specifications 13 through 15 afford the least protection of all listed in Table I.

Explanatory Notes Figs. 1 and 2: Note that no curve is represented as zero MVT, but rather "approach" zero.

Asphalt is included inasmuch as many industrial applications would permit its use.

Correct selection of laminating adhesive would vary the slope and position of curve no. 3.

The use of a film as a "carrier" will change the MVT rating of a material, usually reduce it considerably. The reason is that the film (depending upon its own MVT rating, gage, etc.), though inferior to foil, is far superior to most papers. In sealing pouches (type Ia) the seal edge is less vulnerable because the seal is more positive and is "many mils thick."

CLOSE SPEED REGULATION

wins duplicate installation for RELIANCE engineered paper machine drive . . .

This new single-motor Beloit paper machine, installed by the Detroit Sulphite Pulp and Paper Company in February, 1952, produces top-quality paper at operating speeds ranging from 450 to 1800 fpm.

½ of 1% Regulation

Power is furnished by a 300-hp. Reliance Type 'T' Heavy Duty Drive Motor, with speed control by Reliance V★S Drive. Under all operating conditions, over a 4-to-1 speed range, the Reliance drive system has consistently maintained speed regulation within ½ of 1%.

The management of Detroit Sulphite has been so well pleased with this performance that an exact duplicate has been ordered for a new machine to be installed early in 1953.

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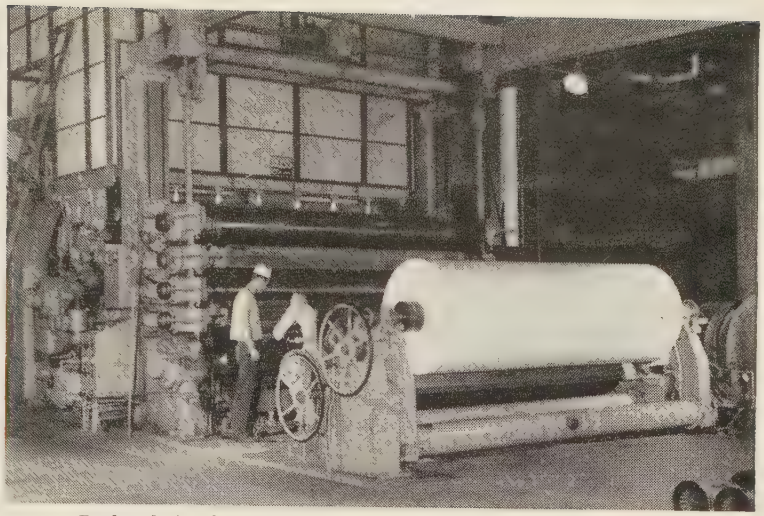
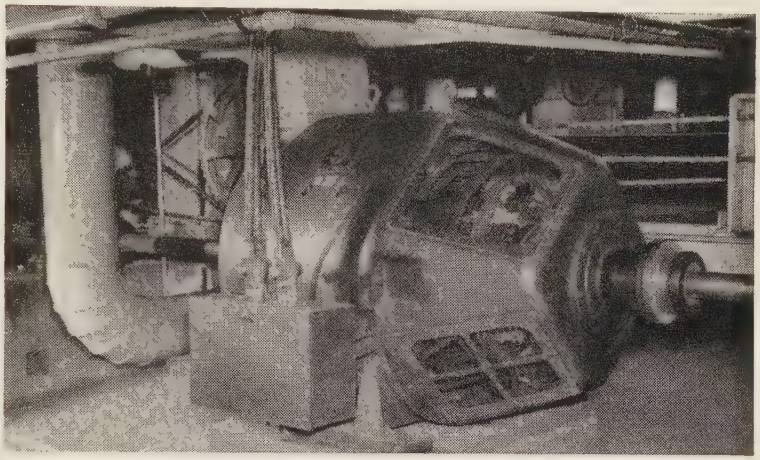
You can cut production costs and improve operation with a Reliance drive on your next machine . . . or on those you now have operating. Write for Bulletin D-2311, describing the Reliance V★S Drive . . . the original all-electric adjustable-speed drive for a-c. circuits . . . or call one of the Application Engineers at any of the 45 convenient Reliance Sales Offices.



Reel end of Beloit single-motor paper machine at Detroit Sulphite Pulp and Paper Company. High-quality paper is produced at speeds ranging from 450 to 1800 fpm.



Power for the main lineshaft drive is supplied by this 300-hp. Reliance Type 'T' Heavy Duty D-c. Motor. Reliance VSR Speed Regulator on the lineshaft maintains speed regulation within ½ of 1% over a 4-to-1 range.

Photographs courtesy of Detroit Sulphite Pulp and Paper Company

Auxiliary drives include this high-speed two-drum winder, powered by a Reliance 50-hp. winder motor. Two other 50-hp. Reliance motors drive the couch helper and the press helper.

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END USE (TABLE II)

Type I—Bags

The use of specification no. 9 for bag type Ib requires a set period. See discussion of heat sealing under wrap over carton type IV.

Using specification no. 9 for bag types Ic and Id can be a combination of gluing and heat sealing, or gluing alone.

Specification no. 13 is preferred over nos. 12 for type Ib to prevent blocking.

Specifications similar to nos. 2, 3, 4, 6 (with film in place of a heat seal coating) sometimes are used as bag type Ib (known as a "pillow package"). There should be a compatible heat seal on the outside surface to make the long seam (as in spec. no. 13) to insure adequate sealing. A film on both sides of the foil would accomplish the same thing. A "pillow-bag" has one possible drawback if foil is contained in the specification;

Fig. 7

the drastic 180° web reversal as the tube is made may rupture the foil component and reduce the protective efficiency to some degree.

Type II

For type IIa, if maximum protection is desired, the over-all caliper of the stock should be as thin as possible to prevent wicking at the seam edges. A 20-lb. per ream paper usually is satisfactory.

Coatings can be applied to prevent reaction between foil and product. Winding adhesives must be selected which will glue foil-to-paper, and be compatible with the product.

For type IIb, the availability of single (inner) pay is not available from most sources; usually, the foil must be laminated to the body stock, and will appear with each turn.

Type III—Liners in a Carton

Type IIIa usually used to keep product from contacting carton board, as for tea, cough drops, etc.

Type IIIb can use specification no. 11 (with spec. no. 8) if the forming mandral is not heated. Otherwise, if the tissue side of 8, 9, or 10 is toward the mandral, the liner may stick.

Type IIIb specifications 8 and 9 used with heating mandrels, should place the tissue side next to the mandrel. The metal or the tissue side of no. 10 can be placed next to the mandrel. Foil ruptures may result if this is not done.

IIIc. Specifications 8–10 afford more protection, but care must be exercised in relative placement of tissue foil and mandrel if mandrel is heated.

IIId. Stencil may be applied by machine in most instances. Stencil on specification no. 13 not heavy enough as a rule.

IIIe. Actually is a pouch (type Ia). Specifications 8 to 11 cannot be used as no "set" period is provided.

Type IV—Wrap Over Carton

IVa. Specification 10 for greater moisture protection, but not for large packages. Seams with 10 can be heat sealed (to insure less wicking along with glue seal) and moisture passage through metal-to-metal folds.

IVb. Specification 10 affords more protection than no. 15, but stencil not necessary. The stencil is applied by machine and is usually wax.

IVc. Selection between specifications 8 to 10 depends upon size and weight of carton. Number 8 usually not used except for extremely small cartons.

IVd. Selection of foil specifications 8 or 9 depends upon weight of carton, and irregularity of carton corners.

IVe. Foil side of specifications 8 or 9 toward carton (choice depends upon IVd consideration, above). Seals of first wrap may be "tacked" if following operation superimposes seals (Fig. 2); some long seam offset should be used. Choice of outer wrap optional between nos. 9, 10, and 11. This style very best protection possible. Used for extremely critical items such as wave pads, dehydrated fruits, powders, etc., for extended storage or shelf life. Replaces can or jar for dry products.

Type V—Wrap Without Carton

This category embraces nearly all of confectionery, dairy, and tobacco uses. Inasmuch as wrap is in contact with the product, the selection of a "carrier" is of prime importance, as well as consideration of "protective" coatings on the "carrier" or foil surfaces. Because intimate contact is desired, embossing is employed for most cheese, butter, and oleomargarine wraps to make the wrap very pliable.

Va. Specification no. 11 used with transparent waxed paper. Also nos. 8 or 15 can be used under reverse printed film to keep out light.

Vc. Chewing gum employs a wax stencil with no. 15 (may be in combination with reverse printed cellophane); no. 13 can be substituted for 5, 6, and 12 in Vd.

Vd. Numbers 8 to 11 could be used with inner liner next to product to prevent wax offset. It is necessary if no. 12 is used.

Ve. Can be used under reverse-printed cellophane and heat sealed.

Vf. Usually as candy bar goods wrap (on a card).

Type VI—Label on Fiber Canister

VIa. Printing cannot have a registered design.

Reprinted from the September 1952, issue of *Flow*.

DORRCO DOINGS IN 1952

The outstanding event in '52 has been the landslide election of General Eisenhower, with Congress Republican by a very small plurality. A year ago I stated "Millions of us here today are thrilled by the hope that we can vote for a really great man, one like our first President, a great General, but above all an able and very wise patriot. No one believes that he would leave his present duties unless he felt that as President he could better serve his country and the world. It is inspiring to realize that he certainly can count on our strongest leaders to help build his team." Now 33 million voters, who gave him the greatest job in the world, must be ready to work as unselfishly for our country and the world as we expect him to do. America has taken heart at the promise of leadership based on unquestioned integrity of mind and character—and I feel all parts of the free world will do likewise.

* * *

RESEARCH AND DEVELOPMENT — We are continuing fundamental studies on classification and sedimentation as well as exploring further applications for fluidizing techniques. The Hydroscillator, first introduced at Tennessee Copper, is extending into other fields, notably low grade iron ore where the trend is towards sharper separations and cleaner sands. Several interesting developments in sewage treatment are currently under investigation. These include an improved digestion process and a method of accelerating secondary treatment.

KRAFT MILL RECAUSTICIZING — We recently conducted a survey in this field, visiting thirty pulp and paper mills, all of which employ the Dorr Continuous Recausticizing System. The main purpose of our visits was to discuss operational trends and to seek ideas for improvement. The general response was gratifyingly favorable and several changes have been adopted which will result in further increasing the efficiency of the Dorr System.

CONSULTING ENGINEERING — Our major design project for the year has been a large triple superphosphate plant for one of America's leading fertilizer producers. Other projects handled this year included such diversified operations as cyanide plants in the Middle East and Africa, a new zinc concentrator in the U. S., further developments in the chemical fertilizer field, and various hydro-metallurgical problems.

ABROAD — All our Associates in Europe and our recently formed Company in India have completed a very satisfactory year. Among our projects starting this year were a phosphoric acid plant in Greece and a kraft pulp mill in Austria. For the latter we supplied a Continuous Recausticizing System as well as a battery of Oliver Filters for the first continuous brown stock washing plant in Europe.

FLUOSOLIDS — The first commercial FluoSolids installation for roasting zinc concentrate went into operation last summer. It is producing SO_2 gas for sulfuric acid manufacture and a desulfurized zinc calcine for leaching prior to electrolytic zinc production. In addition to this installation, eight FluoSolids Reactors at paper mills in the U. S., Canada and Norway are either in operation or under construction to supply major portions of their SO_2 requirements for sulphite cooking liquor.

MUNICIPAL SANITATION — 1952 has been another active year for us in the fields of municipal water and sewage treatment. A very noticeable trend has been the mechanization of treatment plants serving smaller towns and municipalities. Here our complete small-scale plants are providing a high degree of sewage treatment for populations under 5,000.

INDUSTRIAL WATER TREATMENT — Accelerated by the demand for greater product quality control, industrial water treatment is rapidly approaching the municipal field both in size of installations and completeness of treatment. In the first ten months of 1952 we received orders for Dorr water pretreatment equipment which in the aggregate will handle almost 80 million gallons daily. These installations varied from a 600 gallon per hour ion-exchange system for a pharmaceutical manufacturer to a 26 MGD Dorrco Hydro-Treator for a new dissolving pulp mill.

MINE BACKFILL — The compact, highly efficient DorrClone is becoming increasingly popular for mine backfilling operations. One installation at Madsen Red Lake Gold Mines employs two stages to produce 120 tons per day of fill with a percolation rate of 4-6 in/hr. Key to the two-stage DorrClone flowsheet is flexibility. Any type of fill can be produced from practically any composition of mill tailings.

CANE SUGAR — In 1920, United Sugar Companies' Ingenio Los Mochis, one of Mexico's leading sugar producers, put into operation the first Dorr Continuous Cane Juice Clarifier to be ordered, following the initial demonstration at the Cuban American Sugar Company's Central Mercedita. In subsequent years, additional Dorr units were installed as the mill was expanded. In 1952 another Dorr Multifeed was ordered as part of Ingenio Los Mochis' current expansion program, and will go into operation for the 1953 crop. This is typical of the industry's continuing confidence in our sugar equipment.

* * *

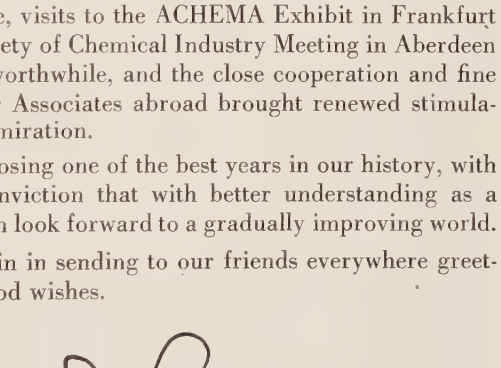
We started the year in Cuba and enroute home saw an industrial revolution in Miami, engineered by MRA, whose principles we have seen working so effectively for industrial and international peace and understanding in many parts of the world today.

Crossing to Europe in May, we spent nearly a month in Spain. The incident of a Spanish Engineer working at Westport 26 years ago resulted in intimate contact with the warmest Spanish hospitality, giving us the feeling that we were privileged to come closer than most visitors to the real Spain. We left, greatly impressed by Spanish progress and the general happy philosophy of the people.

In Europe, visits to the ACHEMA Exhibit in Frankfurt and the Society of Chemical Industry Meeting in Aberdeen were most worthwhile, and the close cooperation and fine work of our Associates abroad brought renewed stimulation and admiration.

We are closing one of the best years in our history, with a strong conviction that with better understanding as a whole we can look forward to a gradually improving world.

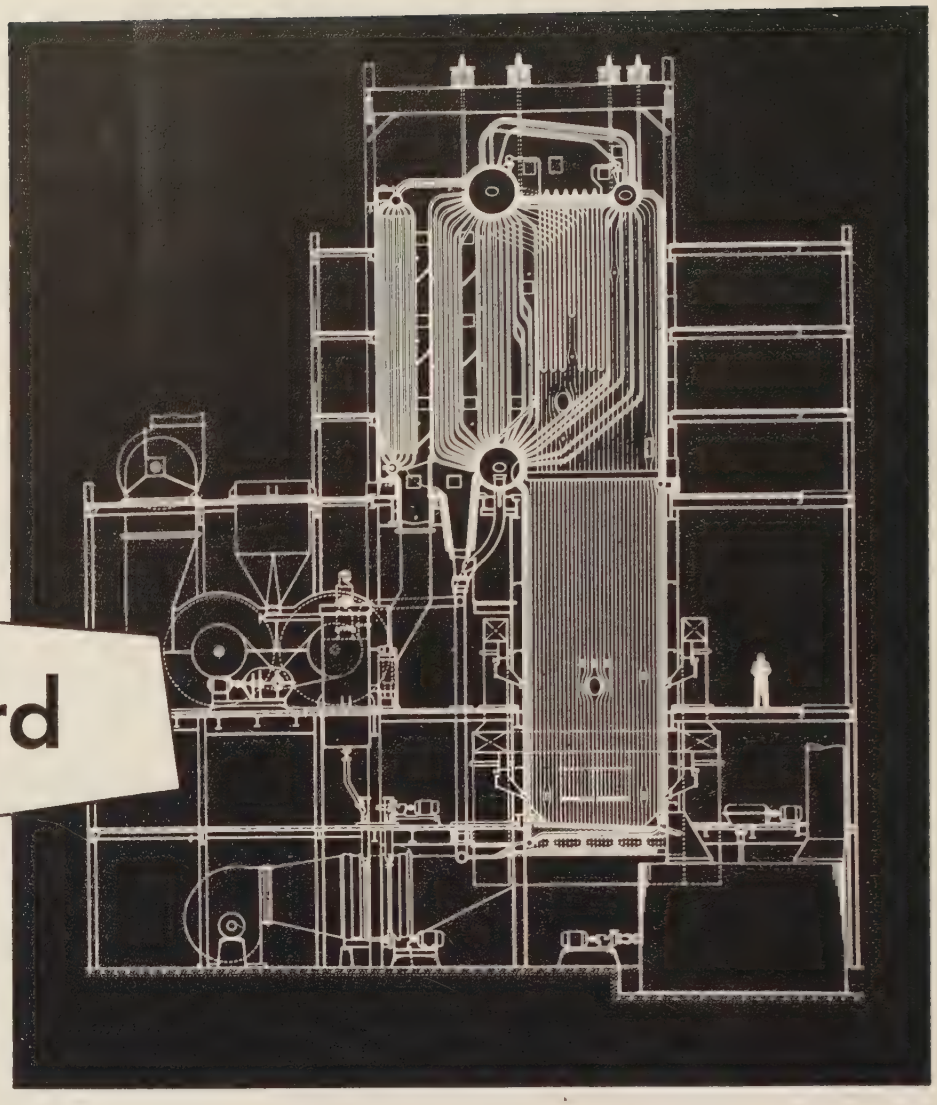
We all join in sending to our friends everywhere greetings and good wishes.



Barry Place, Stamford, Conn.

DORRCO

Now under construction at Bogalusa, La., for the Gaylord Container Corp. is this 350-ton C-E Recovery Unit. Steam is produced at 875 psi and 825 F. It is the fourth C-E Unit at this mill.



Gaylord installs its 4th C-E recovery unit

It was back in 1940, soon after the C-E Recovery Unit had demonstrated beyond the question the merits of its new design features, that the Gaylord Container Corporation of Bogalusa, Louisiana, purchased its first C-E Unit. That was a 175-ton unit.

In 1946, as part of a modernization and expansion program, another C-E Unit of 200-ton capacity was ordered. And again in 1947 another — a duplicate — was purchased.

Work is now under way for the installation of a fourth — and still larger — unit, a cross-sectional elevation of which is shown above.

The order and re-order aspect of this situation is not unusual. Two other large companies have purchased C-E Recovery units on four occasions; two companies have ordered three times and eight companies have ordered twice.

These are the facts. They lead to but one conclusion.

B-628

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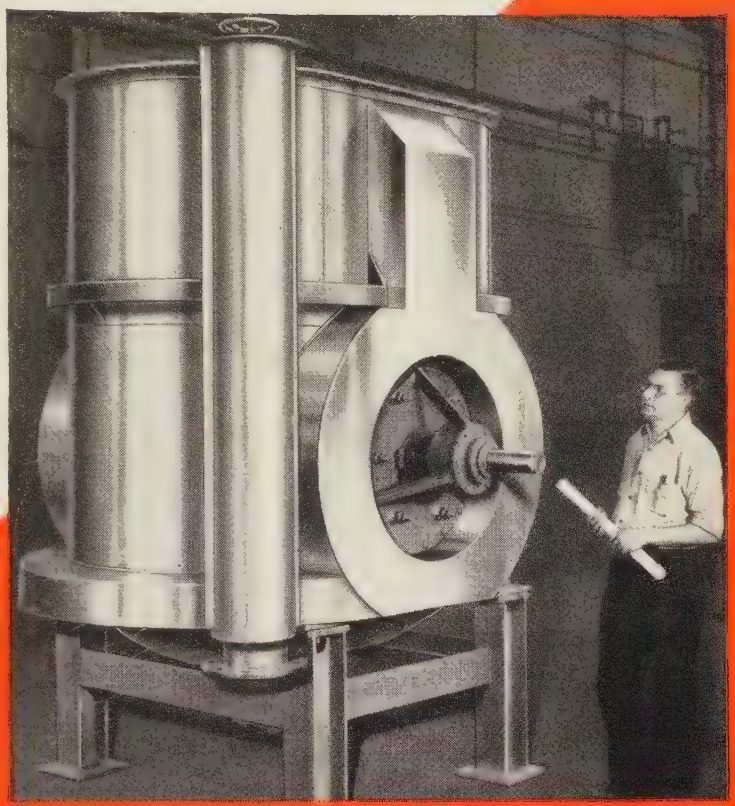

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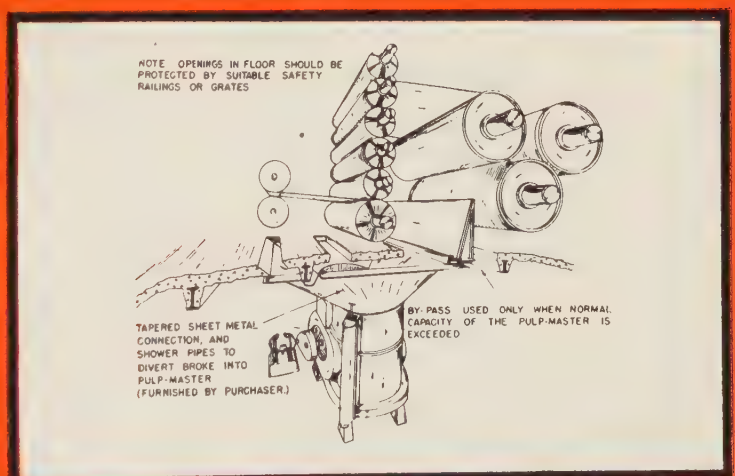
Delivered completely assembled, it is readily anchored in position (see suggested plan at right), piped up and connected to driving motor, ready to do a truly amazing job of pulping broke continuously.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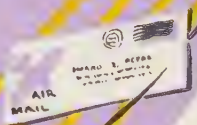

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PAPERS PRESENTED AT THE 1952 CORRUGATING CONFERENCE

Milwaukee, Wis., Nov. 20–21, 1952

The 1952 Fall Corrugating Conference, sponsored by the Technical Association of the Pulp and Paper Industry, was held at the Schroeder Hotel, Milwaukee, Wis., Nov. 20–21, 1952. Over 300 from 23 States and 2 Provinces attended this meeting.

The first day was devoted to papers and discussion with W. R. Tobin, American Box Board Co., acting as moderator. Mill visits were arranged for the following day through the cooperation of the following companies: Cornell Paperboard Products Co., Downing Box Co., and the Gaylord Container Corp.

On Thursday evening, November 20, through the courtesy of the Hooper, Langston, S. & S., and Swift machinery companies those attending spent a pleasant social hour which was followed by the Corrugating Conference Dinner. The speaker was Jimmy Swan, a nationally known humorist.

The program was arranged by the members of the TAPPI Corrugated Containers Committee which include: L. K. Burnett, Ohio Boxboard Co.; M. L. Hamilton, Container Corp. of America; L. S. Johnson, Cornell Paperboard Products Co.; G. G. Johnston, Waldorf Paper Products Co.; M. F. Knack, River Raisin Paper Co.; J. J. Koenig, Gaylord Container Corp.; F. D. Long, Container Corp. of America; W. W. Marteny, National Container Corp. of Wisconsin; K. N. Max, Robert Gair Co.; Burt Mendlin, Cornell Paperboard Products Co.; H. T. Scordas, Union Bag & Paper Co.; W. K. Tobin, American Box Board Co., and E. K. Whitener, International Paper Co.

In addition to the following papers, V. V. Vallandigham, Potlatch Forests, Inc., presented the paper "Problem Analysis" and A. F. Sperling, Downing Box Co., "Corrugator Delivery Tables." Unfortunately these articles were not received when this issue of *Tappi* went to press.

Résumé of Answers to Combiner Questionnaire

H. T. SCORDAS

The TAPPI Corrugated Container Committee is composed of several subcommittees. Among them are committees on corrugator roll wear, high and low corrugations, fingerlines, and heat and moisture control. Before beginning any original work it was decided that these committees would be brought up to date on their respective subjects by canvassing the industry by means of questionnaires. Rather than to bombard the various plants with four separate questionnaires, it was decided to incorporate all of the questions into one, and thus the combiner questionnaire came about.

Now, I would like to thank the representatives of the companies that participated in answering this questionnaire. The response showed definitely that the majority of the corrugated box industry is interested in the exchange of information for its betterment.

For their part in getting up this questionnaire, I would like to thank J. J. Koenig of Gaylord Container Corp., chairman of the subcommittee on high and low corrugations, W. R. Tobin of American Box Board Co., chairman of the fingerline committee, G. G. Johnston of Waldorf Paper Products, Inc., chairman of the corrugator roll wear committee, and James Love of Container Corp. of America for the tremendous job he did in compiling the data on which this discussion is based. We received answers on 61 corrugators. Although I can cover only a small portion of the data assembled, I hope to bring out some of the more important points.

Reported upon were single facers made as far back as the 1920's and as recently as the 1950's. To the best of my knowledge, every recent make of corrugator was reported upon, and of course, all three flutes.

The most common flute reported was A with 23, next was C with 22, and then B with 16.

I am sure that one item of interest to all of us is corrugator speed. One of the questions asked was what is the maximum sustained speed of the single facer when running the maximum width with different weights of liners.

The speeds reported for 42-lb. liners were selected for comparison since this weight is the most predominantly used in the industry. The answers for the three flutes are as follows:

The reported speeds for A flute ranged from 250 to 450 f.p.m. with the average of those reporting being 331 f.p.m.

The C flute speeds ranged from 250 to 475 f.p.m. with an overall average of 339 f.p.m.

For the B flute the speeds ranged from 230 to 510 f.p.m. with an over-all average of 360 f.p.m.

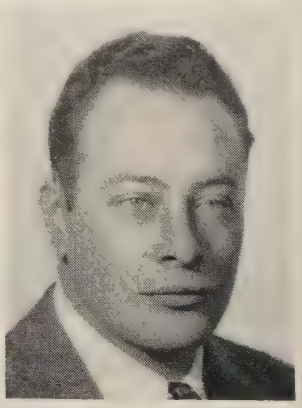
The high speeds were not confined to the latest model corrugators, nor were the low corrugator speeds confined to the oldest models. A 1936 model corrugator was reported to have a maximum sustained speed of 510 f.p.m. with 42-lb. board, and a 1950 model, a maximum sustained speed of 280 f.p.m. with the same board.

The largest diameter listed for the top corrugator rolls was 12 in. for all flutes. For the bottom roll it was 12 in. for A and B flutes and 13 in. for the C flute.

CORRUGATOR ROLL WEAR

With regard to flute height or flute depth of new rolls some

H. T. Scordas, Union Bag & Paper Co.



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variation was noted. The highest or deepest flute reported in A flute was 0.1875 in. and the lowest was 0.180 in. For B flute the highest was 0.105 in. and the lowest 0.097 in. For the C flute 0.145 in. against 0.142 in.

Now as for the wear on the corrugating rolls, the greatest loss in flute height reported on rolls run over 20,000,000 ft. was 0.008 in. There were many companies which reported no loss in flute height on corrugator rolls run over 20,000,000 ft.

Some of the questions asked and the answers received about corrugator roll wear were:

Q. What is the linear footage before changing rolls?
A. The answers varied from 15 up to 500 million linear feet.
Q. Is there a correlation between roll wear and flat crush?
A. 94% answered yes.
Q. How do you determine when to replace rolls?
Q. By caliper of board?
A. 75% said yes.
Q. Cutting at ends?
A. 67% said yes.
Q. By flute depth?
A. 38% said yes.

Some companies, of course, answered yes to two or more of these questions. Another indication reported was the recurrence of loose or wrinkled medium at the center of the sheet.

Seventy-five per cent of the plants stated that they made periodic flute depth measurements, and 57% stated they systematically shifted the line-up to distribute the wear across the rolls.

The rolls reported in use with the greatest linear footage were:

1. A set of chrome-plated 4140 C flute rolls with 231,000,000 ft.
2. A set of chrome-plated 4140 B flute rolls with 174,000,000 ft.
3. A set of regular 4140 C flute rolls with 170,000,000 ft.
4. A set of chrome-plated 4140 B flute rolls with 120,000,000 ft.
5. A set of chrome-plated 4140 A flute rolls with 90,000,000 ft.
6. A set of nitrided C flute rolls with 62,000,000 ft.

Observations regarding these rolls are as follows:

Semichemical medium was by far the most predominant type used.

Three of the six sets of rolls mentioned above ran at a speed of 300 f.p.m. or more.

Four out of six systematically shifted line-up to distribute the wear across the rolls, but none honed the rolls although there were two sets which were not chrome plated. On the other hand, all of these corrugator rolls were checked regularly for parallelism using the carbon paper method.

The suggestions given by these six for increasing the life of rolls are as follows: oil frequently when running; do not run rolls without medium; keep proper alignment; clean and oil rolls; and use maximum width paper at all times.

Other suggestions given for increasing corrugator roll life were: do not idle dry; avoid pressure roll contact with flutes; run graphite periodically; run Bon Ami periodically; run top roll with minimum spring tension, and do not use water on hot corrugator rolls.

HIGH AND LOW CORRUGATIONS

Now with regard to high and low corrugations, all answering generally agreed that by increasing the moisture content of

The TAPPI Corrugating Conference Dinner, Schroeder Hotel, Milwaukee, Wis., Nov. 20, 1952

The SPRINGBOK, national emblem of South Africa.

# of B&W Recovery Units

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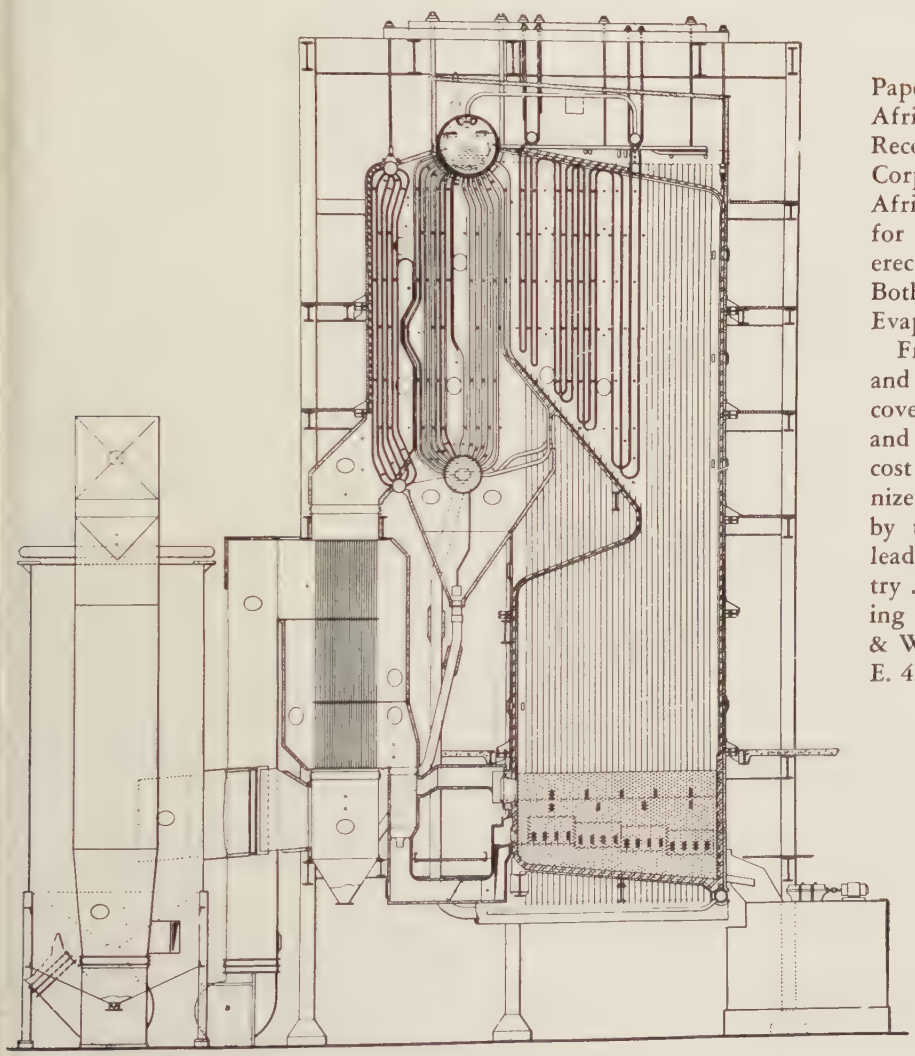

200-Ton B&W Recovery Unit with B&W Cyclone Evaporator for Outdoor Installation in Zululand.

Paper Industries, Ltd. of Springs, South Africa, have been operating a 75-ton B&W Recovery Unit for several years. Union Corporation, Ltd. of Zululand, South Africa, have ordered a 200-ton B&W Unit for outdoor installation; it is now being erected. This represents a repeat order. Both units will have B&W Cyclone Evaporators.

From Oregon to Florida, to Zululand and Finland, the reputation of B&W Recovery Units for highly efficient chemical and heat recovery, reliability, and low-cost operation and maintenance, is recognized. It is a reputation firmly established by the performance of B&W Units in leading mills throughout the paper industry . . . a reputation that is rapidly reaching world-wide proportions. The Babcock & Wilcox Company, Boiler Division, 161 E. 42nd Street, New York 17, N. Y.

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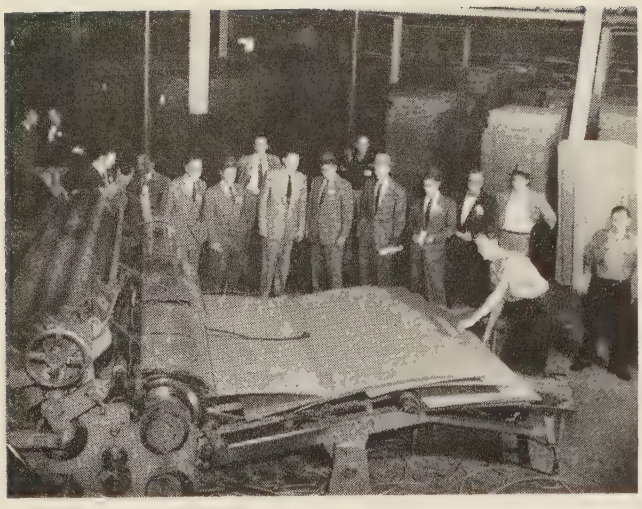

Corrugated printer-slotter at the Gaylord Container Corp.

the medium the frequency of high and low corrugations was reduced.

Those who used more than one type of medium generally agreed that kraft and bogus have a greater tendency to produce high and low corrugations than semichemical medium, and bogus more so than kraft. Very little information was obtained about chestnut and straw regarding the tendency to produce highs and lows.

The principal causes given for high and low corrugations were: dirty corrugating rolls, uneven corrugating rolls, excessive clearance between corrugator roll and glue roll, hard finished medium, low moisture content medium, rough running machines, i.e., poor bearings and drives, poor operating techniques, and poor heat transfer.

The recommendations on how to eliminate high and low corrugations varied considerably. The most predominant answers were: more slow down, keep rolls clean, keep the fingers as close as possible to the corrugating roll, adjust brake and roll tension, increase steam, and oil rolls.

One of the questions asked was what clearance is generally maintained between the glue applicator roll and the corrugator roll. The answers varied from 0.040 to 0.010 in. with an average of 0.028 in. We compared the remarks of those using high clearances with those using low clearances and were not able to determine any correlation between clearance and high and low corrugations.

All but one corrugator reported using spring tension for loading the top corrugator roll. This gave no opportunity for evaluating the effect of type of loading on highs and lows.

Twenty-three corrugators reported using constant tensioning straw feeders. The majority using these felt that their use reduced the frequency of high and low corrugations, but to a very limited degree.

Another difficulty reported on is that of bed-down of medium in the slots of the top corrugating rolls. Some of the recommendations given for the elimination of this condition were: (1) reduce tension on medium, (2) cut down the steam showers and dry out medium, (3) adjust corrugator rolls laterally, (4) use paraffin oil on rolls, and (5) reduce pressure between corrugator rolls.

FINGERLINES

In the section of fingerlines, we found that the types of fingers reported in use varied practically from corrugator to corrugator. The adhesive used appeared to have no bearing on the type of fingers preferred, with the exception that the eight reporting having fingers notched in the relief used starch as the adhesive.

In answer to the question whether fingers were adjusted singly or in unison, the great majority reported adjusting the fingers individually. Now as to type of adjustment possible for the fingers, that is horizontally, vertically, or axially, every combination involving these three was reported.

With regard to finger life in terms of linear feet of board produced, the maximum average life reported was 14,000,000 ft. and the minimum 1,000,000 ft. The over-all average life was 4,000,000 ft. For chrome-plated fingers the reported average life was 6,000,000 ft.

Six out of fifty-one reported complete elimination of fingerlines and forty reported partial elimination. All of the six reporting complete elimination used starch.

The methods recommended by these six for reducing or eliminating fingerlines are as follows: two advised a large clearance between corrugator roll and fingers, one advocated keeping the corrugator rolls and fingers clean, one recommended daily inspection of board and adjustment of fingers, and weekly maintenance of fingers, one advised the removal of the cleanout rings and the notching of the fingers, and one recommended the use of a special design of smoothing roll but furnished no details. All the above recommendations except the last conformed to those given by the rest of the industry.

For the adhesive used at the single facer forty-nine listed starch, three used starch and silicate intermittently, eight used silicate, and one listed a silicate clay mixture.

At the single facer the average starch consumption of the 52 reporting was 1.3 lb. per 1000 sq. ft., the maximum reported usage was listed as 1.75, and the minimum 0.98 lb. per 1000 sq. ft.

With regard to silicate consumption, the average at the single facer was 7.7 lb. per 1000 sq. ft.

HEAT AND MOISTURE CONTROL

On heat and moisture control it was found that the average steam pressure reported at the single facer was 159 p.s.i. The highest reported pressure was 200 and the lowest 125 p.s.i. The majority of the steam pressures reported were between 160 and 180 p.s.i.

The surface temperatures of the corrugating rolls ranged from 290 to 365°F., with the average being 335°F. and the predominant range 330 to 350°F.

The answers to the questionnaires showed that about 97% of the corrugators were provided with auxiliary preheaters for the liners at both the single facer and the double backer, and 78% were provided with preheaters on the bridge for the single face board. Twenty-nine per cent of the liner and single face board preheaters were driven. The most predominant diameter was 36 in., and the preheaters generally carried the same steam pressure as the single facers.

With regard to side heated, approximately 80% preferred to heat the liners from the inside.

Ninety-seven per cent of the corrugators used exhaust steam to condition the medium at the single facer, and 54% were provided with preheaters for the corrugating medium. The predominant diameter of these preheaters was 24 in.

The lengths of double backer hot plate sections reported varied from 54 to 26 ft. The average length was 40 ft. The number of plates reported varied from 33 to 13 with the average being 24. The maximum amount of hot plate sections reported was seven and the minimum one, with the average being three.

Forty-three out of sixty-one reported it possible to regulate the steam pressure at the double backer by sections, but only 15 reported the use of semiautomatic regulators.

With respect to the type of moisture control exercised at the corrugators, the use of preheaters and machine speed were the most predominant methods reported. However, the use of steam showers, the regulation of steam pressure at the hot plate sections, and varying the adhesive spread were additional means reported for controlling moisture content.

Eleven plants reported using auxiliary devices such as blow-

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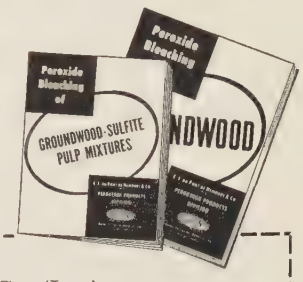
The experience of Consolidated with the peroxide bleaching process is typical of reports from many paper mills in the U. S. and Canada. Technical service and assistance is available from Du Pont field men, pioneers of the peroxide process for groundwood bleaching. For more information, send in the coupon below for our new booklets, "Peroxide Bleaching of Groundwood" and "Peroxide Bleaching of Groundwood-Sulfite Pulp Mixtures."



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C. R. Vander Meulen, Penick & Ford, Ltd.

W. R. Tobin, American Box Board Co.

ers and suction fans for aiding in the moisture control of the combined board.

In general, it was found that the speed of the corrugator was limited by drying capacity when the weight of liners exceeded 42 lb. It was observed that those limited by drying capacity when using 42 lb. or lighter liners carried a low steam pressure, a short hot plate section, or a combination of the two.

One question asked was what is the moisture content of the various weight liners used? Although the answers varied it was interesting to note that, in general, liners above 42 lb. contained an average of about 1% more moisture than those of 42 lb. and below. Thus, when using heavy weight liners, the drying capacity is burdened not only by the added weight, but by the increased moisture content of the components.

Reported steam consumptions varied from 12.1 lb. of steam/1000 per sq. ft. of board produced to 105 lb. of steam. The over-all average was 55.2 lb./100 per sq. ft. of combined board. In terms of pounds of steam per ton of board the maximum reported was 1290 lb., the minimum was 166 lb. with the average being 777 lb. of steam per ton of board.

Although the answers indicated that the industry employed a good many types of condensate removal systems, the great majority appeared to be satisfied with the functioning of its particular system.

Now, I realize what I have reported to you is pretty well generalized. However, each subcommittee will now examine its portion of the questionnaire in far more detail. From their findings, they will plan their future work, which I am sure will bring to light a good many answers to the many problems now confronting the industry.

Warping and Washboarding

C. R. VANDER MEULEN

THE subject of warping and washboarding is an important one to the corrugating industry. These problems are of such a varied and complex nature that they preclude any simple solution. I will present some of the probable causes and corrective measures which may be employed to minimize these difficulties.

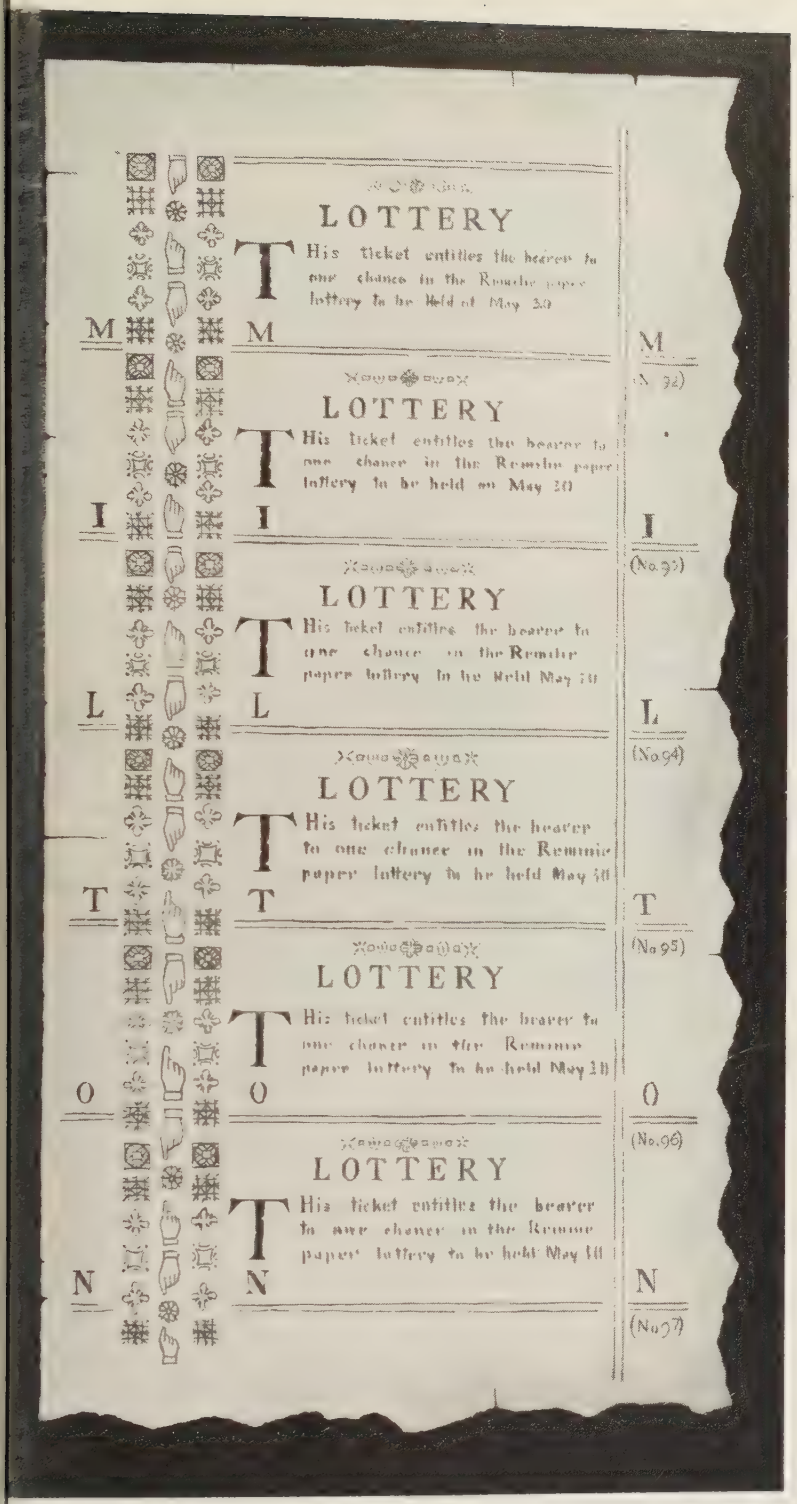
The references to these problems in the various publications are brief and sketchy. These difficulties have occurred, however, at least to some extent, in every corrugating plant. No doubt they have been discussed and worked on by everyone concerned with the production of corrugated board from the paper manufacturer, the fabricators of corrugating equipment, the adhesive suppliers to the personnel of the box plant including the operators of the machines.

Warping may be defined as a distortion of the board from a perfectly flat condition into various curved patterns. A lengthwise warp has a curvature either up or down with its axis in an across-the-machine direction. It is generally agreed that this type of warp is caused by an unbalancing of the tension of the liners and its remedy is an equalizing of the tension. A normal warp has its concavity on the single face side of the sheet with the axis parallel to machine direction. A reverse warp, which occurs infrequently, would be just the opposite of a normal warp. Other types of warping which have been reported and which are most difficult to control are the diagonal or twisted warp and the S warp. The twisted warp has its axis diagonally across the board, while the S warp has a double curvature with two axes in the machine direction. Washboarding is a self-descriptive name of the appearance of board having a concaveness or indentation of the liners between the flutes in an across-the-machine direction. Warping and washboarding are conditions that may occur regardless of type of adhesive, corrugating machine, or components, although the seriousness of the difficulty will vary with components and the care and control used in the process of fabrication.

Warping of corrugated board causes difficulty in handling the board, in building the loads, and the loads are unsightly. Warped board is difficult and sometimes impossible to run through the printer-slotter. An increase in waste results from throwing out of sheets. If the warping is serious, the finished box may not be square and a decrease in compression may result due to crushing when warped sheets are run through the printer-slotters. Washboarding results in poor printing jobs and some loss in flat crush strength.

The few published references to warping all indicate that it is caused by unbalanced moisture content in the components and the board or to improper heat balance. I believe the latter is inferentially the same as the former since it is by control of heat or heat balance that we attempt to eliminate or control the unbalancing due to moisture. The source of the moisture which causes the difficulty would be the moisture content of the components, that imparted by steaming the medium and that introduced by the application of adhesive. Since, by far, the greatest percentage of distortion is a normal warp, it is considered unlikely that unequal moisture contents in the two liners have too great an effect because it would be beyond the realm of probability that the rolls of paper would be placed so as to continually cause this type of distortion. Extreme differences might have an effect on some of the more infrequent types of warp. Some other variables which might have an effect are the alkalinity of the adhesive, dimensional changes in the adhesive film on drying, and the dimensional stability of the paper which will vary with the type of furnish, density, two-sidedness, loading, machine conditions, moisture content, and receptivity to moisture. Also, liners of widely different caliper, weight, or furnish will frequently result in warped board. The principal factor which causes warping, however, is considered to be moisture and, more important, the dimensional changes produced in the components and board by an unequal distribution of the moisture during the process of manufacture. This paper will consider primarily the developing of a theory of how the most frequent normal warp occurs and will offer suggestions for its control. The development of a theory as to how and why the dimensional changes caused by unbalancing of moisture content can cause warping and the corrective measures suggested are likely to be highly controversial. This is attested by published statements in which one author advocates increasing wrap on the preheater to control warp and another author advises reducing the heat on the preheater or, in effect, decreasing the wrap. Some operators stress shrinkage of the paper and others believe expansion has the greatest effect. Still further disagreement exists in that we have had some operators insist that warp may be reduced by increasing the amount of adhesive, while others prefer to reduce the amount of adhesive applied.

C. R. VANDER MEULEN, Technical Sales Dept., Penick & Ford, Ltd., Inc., Cedar Rapids, Iowa.



Paper Mill Financing 1782 Style

MANAGING a paper mill in the 18th Century was a serious affair. Paper making was regarded as a sort of public utility, and was held under the watchful supervision of the Government "commissions" of that time. Then government regulations contained many "don'ts" and few helps. As a result, financing was always a problem to paper makers, since the official "grants" rarely carried more than permission to engage in business.

In 1782 the Milton Mill in Massachusetts needed money badly, and got official permission to run a lottery . . . another example of the resourcefulness of paper makers.

Difficulties of one kind or another always seem to have been the unwanted guests of paper manufacturers. Theirs has always been a constant struggle to improve the utilization of men, materials and machinery, to meet an ever-increasing demand for paper.

Pennsalt research chemists eagerly welcome the opportunity to help manufacturers boost production and lower costs. Specific inquiries are invited. *In the East:* Pennsylvania Salt Manufacturing Company, Philadelphia 7, Pa. *In the West:* Pennsylvania Salt Manufacturing Company of Washington, Tacoma, Washington.

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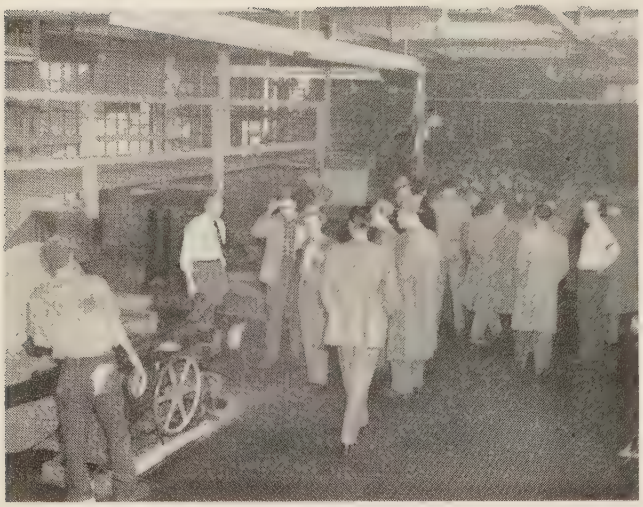

A corrugating machine at the Cornell Paperboard Products Co.

It is a known fact that paper expands and contracts more in a cross direction than in a machine direction, usually in a ratio greater than two to one. Time did not permit a thorough study of the various relevant data on this subject but it is referred to in James P. Casey's (*1*) book on pulp and paper and the International Critical Tables (*2*) have a composite curve for all papers showing the variations in dimensions with variation in relative humidity These data, based on 65% relative humidity, indicate a change in cross-grain dimension from −0.5% at 10% R. H. to +0.5% at 85% R. H. In a machine direction, the change may be from −0.2 to +0.2%. Using these data, only for the purpose of illustration and assuming that such extremes may occur under the conditions of heating and steaming prevailing on a corrugator, a sheet of paper 84 in. wide could conceivably vary in width by more than 0.8 in.

In considering the effect of heat and moisture, the paper may be considered as two-sided, i.e., there is a differential effect with one side being drier or more moist depending on the particular treatment at that instant with the result that the side having the higher moisture content will be in a more expanded state than the other, causing a concaveness toward the dry side. In the corrugating operation, we must visualize this condition as almost instantaneous but never extreme and there is probably no instant where complete equilibrium is reached as the board is being formed. I am asking you to visualize this differential effect as a surface effect only, to show the tendency to curl up or down. Just how much effect this differential action has is difficult to say, but I think we will all agree that it will have a pronounced effect on warping. We must also remember, however, that there will be a dimensional change in the entire width of the sheet as it is heated and dried and later is cooled and again absorbs moisture.

You of the corrugating industry are familiar with the terrific beating you give the components as they are steamed, moistened by water from the adhesive, heated, cooled, and subjected to tension, pressure, and bending, all within the short time it takes to go through the machine. The components are therefore subjected to a rapid and very drastic series of fluctuating forces. As the paper passes over each preheater or is steamed or cooled or moistened, there should be a change in dimension caused by varying moisture content tending to cause a curl or concaveness in one direction or the other. These changes occur so rapidly that they cannot be seen, but a little thought as to what might occur at each instant will enable you to visualize the tendencies. A few of the more important facts are worth mentioning. The corrugating medium is both heated and steamed. These treatments, as I picture the effect, tend to counteract each other and so there is little final change in lateral dimension. The single face liner is heated and dried by the preheater and this would tend to create a contraction in width. When the two components are brought together with the adhesive between them, the space between the flutes should be very nearly saturated with steam produced from the aqueous adhesive and inherent moisture in the stock. The single face web has considerable time to approach a state of equilibrium permitting absorption of some of the moisture into the paper. The medium having a larger area exposed, and usually being more absorbent, should pick up the most moisture. This should result in the surface next to the liner having a higher moisture content with a resultant curl downward or away from the liner. This tendency to warp downward is shown, I think, by the fact that some of the corrugating machine manufacturers have recommended and installed crowned rolls for improving the contact of the flutes at the double backer glue roll. When the single face web passes through the double backer glue station the adhesive picked up will tend to moisten the flutes, and a curl upward may be observed in the web between the glue station and hot plate section. This is always noted when the machine is idle.

The bottom liner is passed over a preheater usually with the outer surface in contact. Through the hot plate section the outer surface continues in contact with the heating surface. Since this heating will drive any moisture present toward the inside surface of the sheet the tendency for curl should be downward. An extensive over-all contraction in the width of the sheet should also result.

The single face web having picked up the adhesive at the double backer and the double backer liner are brought together under the belt at the entry of the hot plate section. Moisture will be flashed from the adhesive almost instantly. It will tend to be absorbed upward into the medium, single face liner, and belt and be driven outward through the flutes by air expansion. I believe the greater portion of the vapor will be on the lower side of the medium and toward the outer edges of the board. Again the medium, having the larger exposed area and being more receptive, should have a higher moisture content on the surface next to the bottom liner and this should result in a concavity toward the single face liner. The bond is being formed meanwhile as the bottom liner is hot and dry and therefore in a contracted state and as the components are being held flat by the belt. If the bottom liner is in too much of a contracted state when the bond is formed, expansion as the board comes to equilibrium will cause a concaveness upward. The sheet will be delivered in a perfectly flat condition but if the dimensional stability has been so disturbed as described above a warping will begin almost immediately.

According to this theory then, most of the distortion resulting in a normal warp occurs in the hot plate section. Conditions occurring previously will have their effect especially in helping to control this type of curl as will be described later. A reverse warp will occur if conditions are the reverse of those resulting in an upward warp and its control also would be by means opposite to those employed for reducing normal warp. The S warp has been explained as being caused by a wet edge or streak parallel to machine direction of the paper. Its correction would seem to be primarily a problem of the paper mill. If the roll has a wet streak, it may be set aside to allow some equilibrium or leveling out to take place by absorption of the moisture from the wet to drier areas. It is problematical whether this will take place in a short time. I have just recently been advised that one plant having difficulty with an S warp discovered a steam leak in their last hot plate. Repairing of the leak quickly eliminated their difficulty. The twisted or diagonal warp is more difficult to explain. An uneven moisture condition has been suggested as the cause. Other possibilities are a misalignment of the rolls, cross tension due to uneven draw in the belts, or a built-in distortion occurring in the process of paper manufacture.

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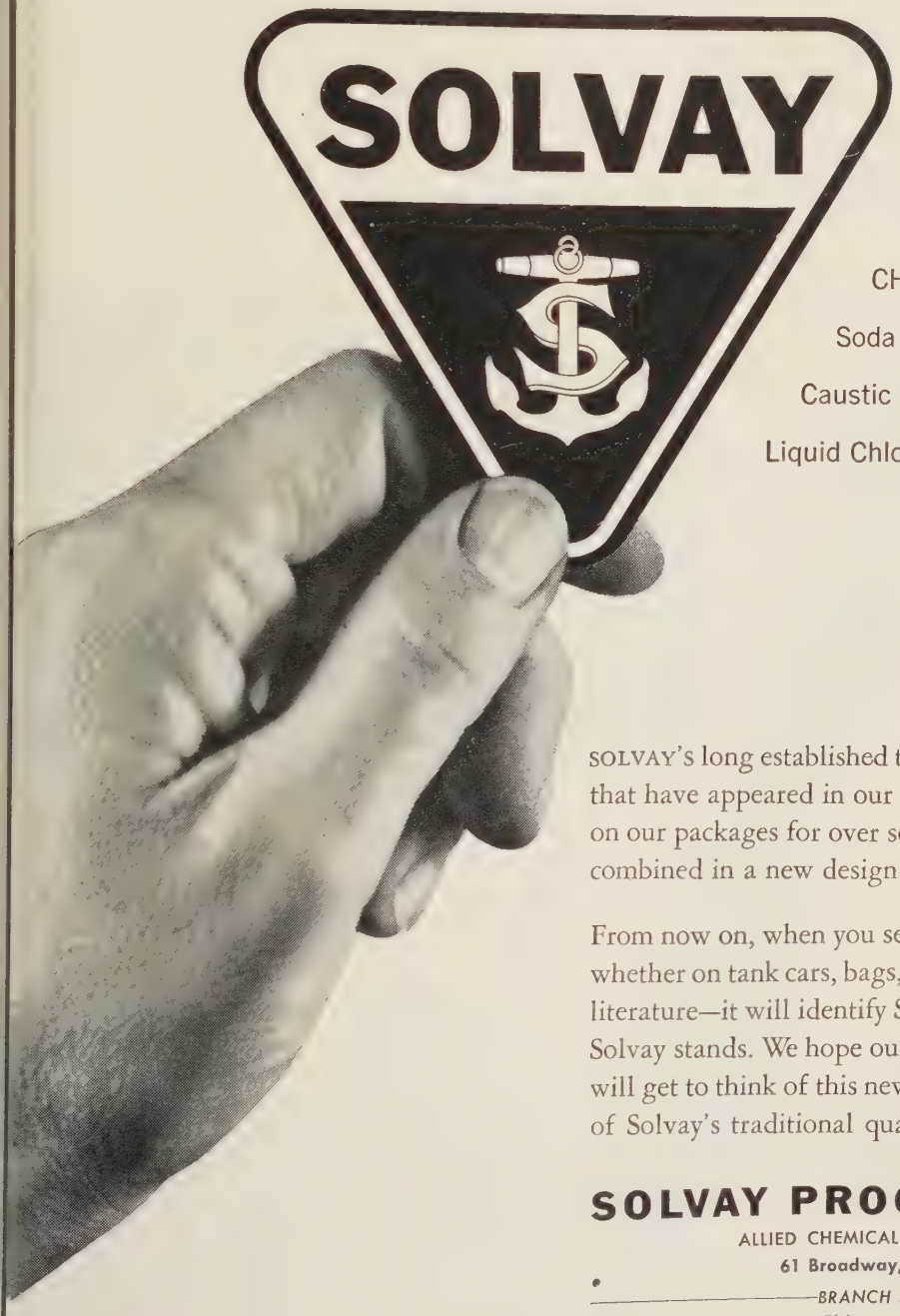

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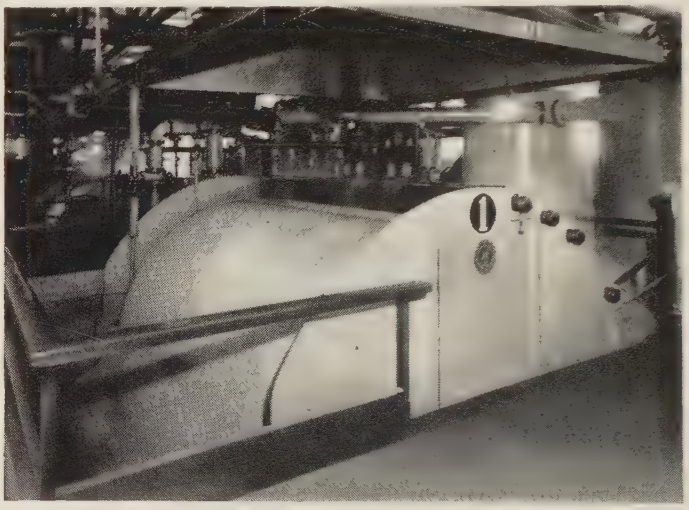
The following methods of employing preheaters is suggested for control of normal warping.

1. Increase the wrap of the liner on the single face preheater. This would provide for the maximum contraction of the liner before bonding and its subsequent expansion, when the finished board comes to equilibrium, would counteract that of the bottom liner.
2. Decrease the preheater wrap of the corrugating medium. This would minimize shrinking of this component so that a minimum of expansion will occur later when it is subjected to moisture in the hot plate section.
3. Increase the wrap of the single face web on the preheater on the bridge. The web should be run with the liner in contact with the preheater. This will again provide for contraction of the liner which may have expanded to some extent during its passage over the bridge. The maximum contraction is desirable as explained in item 1, above.
4. Decrease the wrap of the double backer liner on the preheater. This will tend to decrease contraction of the liner so that expansion will occur to a lesser extent in the finished board.

It is probable that no one of these suggestions will give complete control but that combinations of two or more will be required to even minimize the difficulty.

The suggested uses of preheaters as corrective measures have considered only variation in the amount of wrap. A recent trend of thought to give this same effect is to provide for temperature control of the preheaters so that a full wrap may be maintained while the temperature is varied to give the control desired. The question here is whether the desired changes in temperature could be obtained in a short enough time. It has also been recommended that running at higher speeds will minimize warping. This, in effect, would be the same as lowering temperatures on the double back liner or making the effect of the heat less extreme. If this theory is correct, we would also require additional heat on the single face liner where higher temperatures or larger preheaters might be provided. Where machine conditions do not permit increased speed and so long as adhesion is not affected, it has been recommended that sectional control of the hot plate temperature be provided. In this connection, we have, for a long time, recommended that reducing valves be installed for controlling the temperature of the various hot plate sections especially where lightweight liners are being run.

In considering the components themselves, we must leave to the papermakers the job of furnishing them as troublefree as possible. A uniform moisture content is mandatory avoiding wet streaks, wet edges, and variation in moisture from roll



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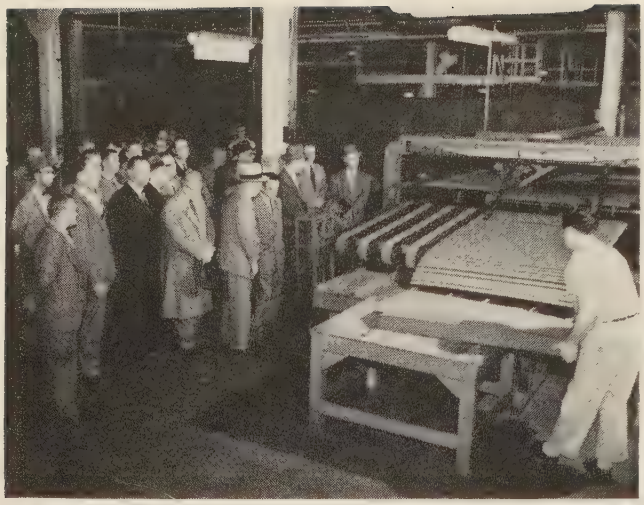

Corrugator delivery at the Downing Box Co.

to roll. In order to obtain as much dimensional stability as possible, all precautions should be used to avoid wild formation.

When running dissimilar liners, i.e., cylinder and fourdrinier or light weight and heavy weight, considerable difficulty is likely to be realized. Special care is then required to obtain heat and moisture balance. Probably the best advice is to avoid such combinations as much as possible.

When calender sizing liners on the paper machine, curling is frequently encountered if the sizing solution is used on only one side of the sheet. This application has been found advantageous when laminating certain components to produce lay-flat board. For extreme cases and especially where a normal warp is considered, we may be able to take advantage of this fact. The application of a calender solution to the inside of the single face liner would induce a downward curl. A similar application to the outside of the double backer liner would likewise tend to offset normal warping in addition to improving the printing surface.

Steam showers might be used on either liner to induce a reverse curl but this is contraindicated since in most cases we are already faced with high moisture levels approaching the range which cause difficulty. At the double backer, however, where according to the theory, most of the warping occurs, we have a condition where as much heat as possible is desired for setting the adhesive and yet at the same time, the heat will cause difficulty by causing too great a contraction of the paper. Perhaps judicial use of a steam shower or even a fine mist of water sprayed on the outside of the double backer liner might tend to induce a reverse curl and at the same time prevent excessive contraction of the sheet. Steam showers are necessary for conditioning the corrugating medium but excessive steaming can result in excess moisture which may increase warping tendencies.

The displacement of the moist air in the flutes has been considered but no practical way has beeen found to accomplish this on the machine. It has long been my opinion that some further thought and experimenting be carried on along this line. The use of a large suction box for removal of the moist air after the board has been stacked is considered of benefit in producing drier board.

The amount of adhesive used will also have a material effect on warping. In general, a consensus indicates that the use of excessive adhesive is objectionable. This is logical since the use of excessive adhesive of any kind would introduce additional water and it is the effect of unequal distribution of moisture that we are trying to overcome. Some authors advise using less adhesive at the single facer and more at the double backer for eliminating a warp which is concave toward the single face liner. I will agree with the former, but, in my opinion, adding more adhesive at the double backer will only introduce more water and its effect, as explained previously, should create more expansion on the bottom side of the medium and thus increase the warping tendency. For best results therefore, and for economic reasons too, it is advisable to keep the adhesive consumption at a minimum.

The question may be asked—why not use fewer gallons of a high solids adhesive to introduce less water? We must keep in mind that there is a minimum gallonage beyond which we cannot go and still obtain satisfactory coverage. Most of the manufacturers are already using less than 2 gal. per 1000 sq. ft., and so it becomes apparent that there are limits in regard to the amount of solids which can be used. Vice versa, it is not considered advisable to extend the adhesive by using low solids but rather keep them in as high a range as practicable.

In regard to adhesive viscosity, most operators believe that the use of a higher viscosity tends to be a corrective measure or causes less difficulty. Perhaps the two-viscosity system would be of benefit since the optimum conditions could then be maintained on both stations. Very fluid adhesives, particularly those carrying a low percentage of bound water, will show excessive subsurface penetration and it will be necessary to increase the clearance to apply more adhesive to obtain a satisfactory bond. Therefore, a higher viscosity adhesive containing more bound water is recommended. It must be realized that with a higher viscosity, with any given setting, more adhesive will be carried through the rolls and rolls clearances can therefore be reduced, eliminating excess adhesive. The use of both synthetic and natural colloids and other additives may be of assistance—the colloids because of their hydrophilic and viscosity stabilizing characteristics and clays or diatomaceous earths for increasing solids content. The use of small amounts of ketonic resin for stabilizing viscosity and increasing bound water content has been discussed in earlier publications (*3*). If the viscosity of the corrugating adhesive can be maintained in a narrow range, we can be assured of the application of a continuous uniform amount of adhesive and avoid the application of varying amount of water.

Now a few words about washboarding. This defect is more difficult to explain and correct. It is caused by a dimensional disturbance parallel to the machine direction of the paper. Some of the contributing factors which cause this dimensional change are: (1) expansion of the liners at point of contact with flute due to water from adhesive, (2) expansion of corrugating medium due to steaming and high moisture conditions prevailing in hot plate section, (3) pressure of rolls at single facer and rider rolls and belt in hot plate section, and (4) contractive force of the adhesive on drying.

Liner shrinkage has been given as a cause for washboarding. It seems more likely that shrinkage would pull a particular liner taut and, a straight line being the shortest distance, the liner could not possibly assume a curved position between the flutes. If one liner should shrink more than the other, the entire board might contract accordion-like, forcing the excess paper of the other liner into the valleys of the washboard condition. If such a condition occurred, the board on the top of the load where not held flat should rather be forced into a lengthwise warp. If both liners shrank, drawing up the board accordion-like, a change in the total length should be easily measured. The liners are subjected to counteractive forces of tension and contraction due to the heat driving off moisture as they enter the machine. These forces are probably very nearly in equilibrium especially since tension is watched closely to prevent lengthwise bowing. When the liners come into contact with the flutes, they are moistened by water from the adhesive at point of contact. An expansion should occur at this point and if the bond is formed while the paper is expanded, the extra length provided by the expansion would be sufficient to cause the valley or indentation between the flutes. Expansion of the flutes in a vertical direction

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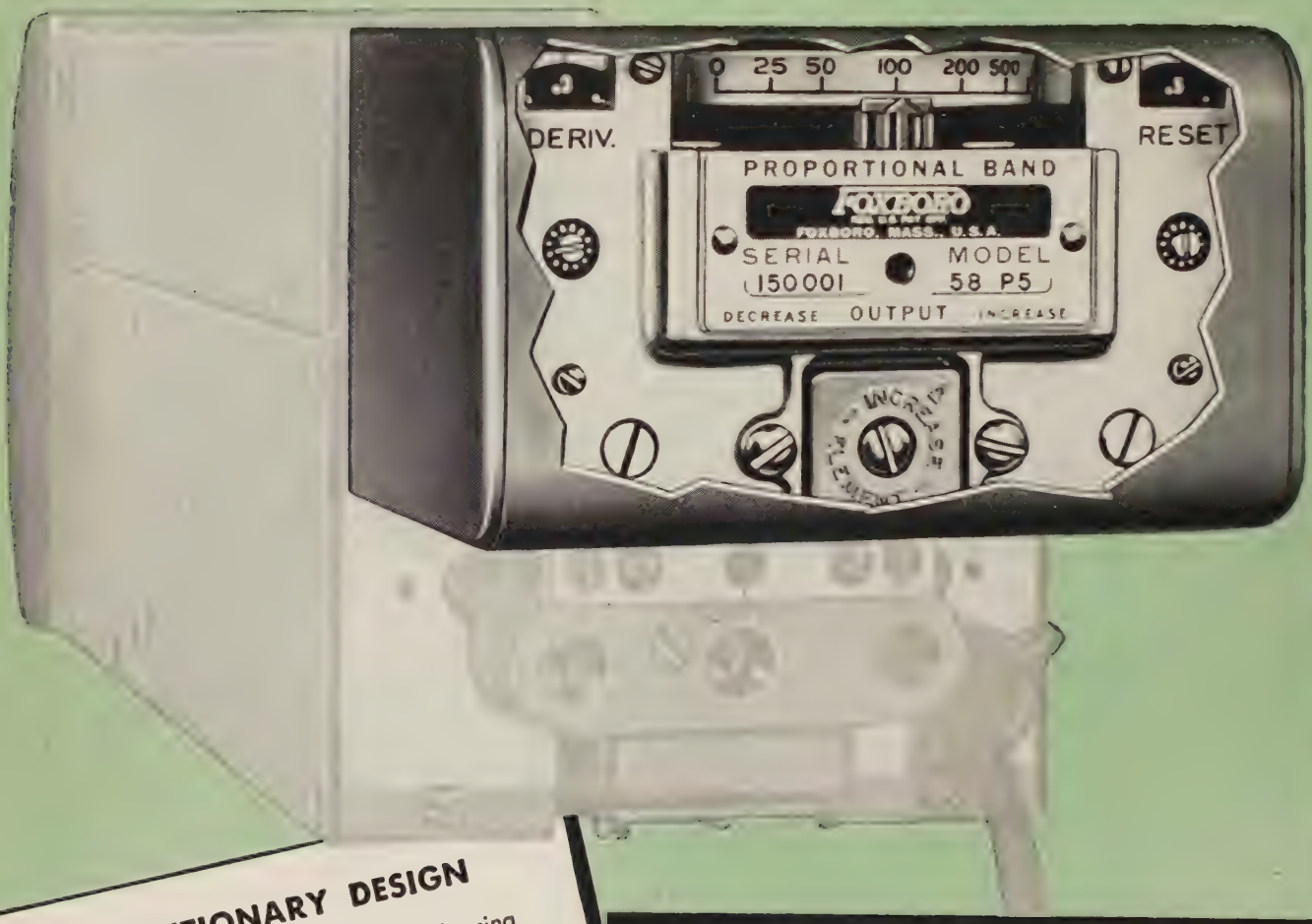

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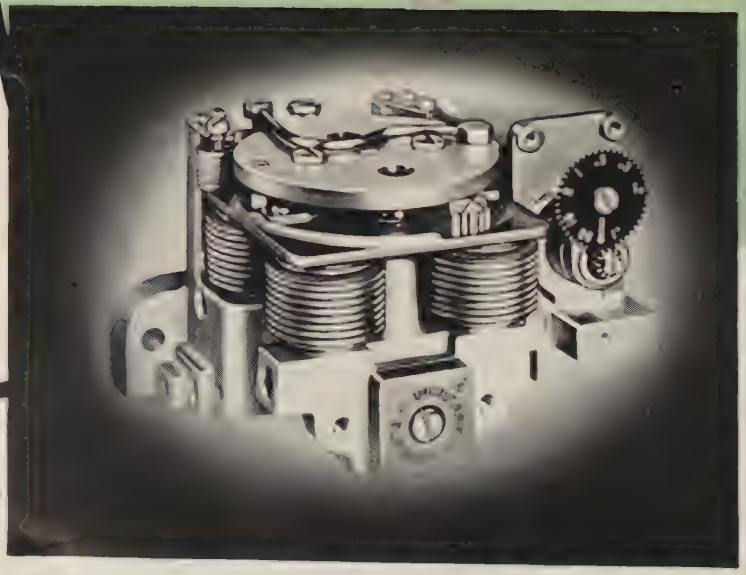

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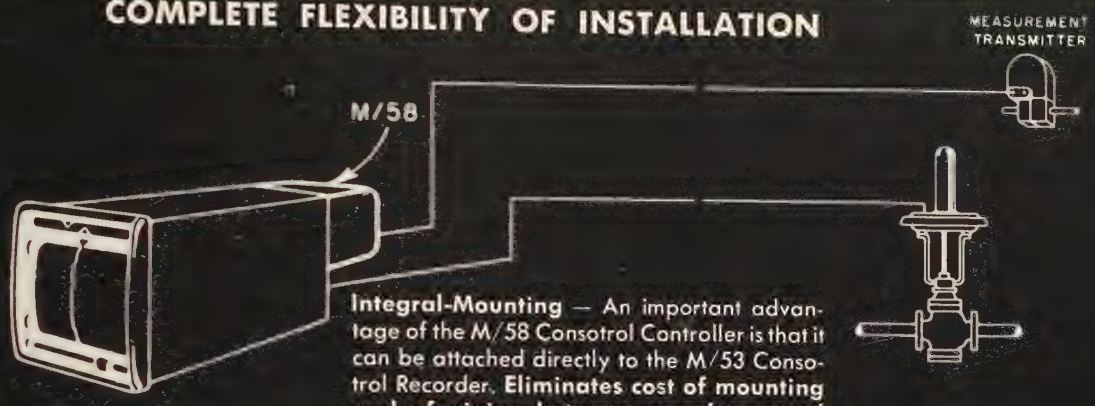
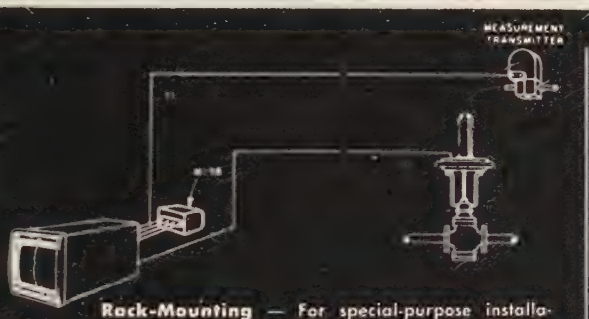


Integral-Mounting — An important advantage of the M/58 Consotrol Controller is that it can be attached directly to the M/53 Consotrol Recorder. **Eliminates cost of mounting and of piping between panel-mounted recorder and the controller.**



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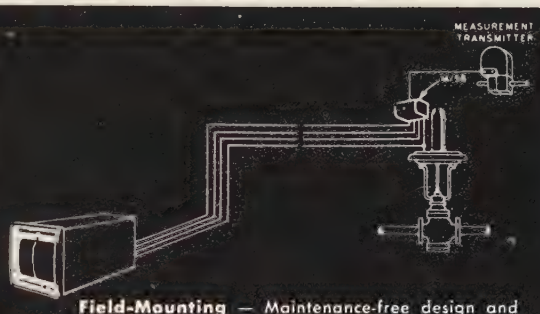

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Write for Bulletin 463 containing full details of the M/58 Controller together with the full line of Consotrol Instruments. **The Foxboro Company, 781 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities.

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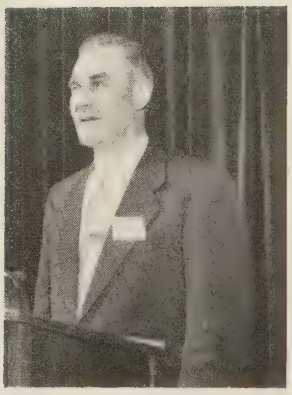
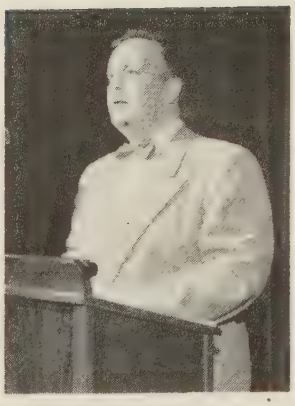


F. E. Skiver, American Box Board Co.



A. F. Sperling, Downing Box Co.

should also occur under the high humidity conditions prevailing in the board. This should provide for more contact at the shoulder of the flute. At the single facer there is a definite pressure between pressure roll and corrugating roll and in the hot plate section, pressure is provided by the belt and rider rolls to squeeze the adhesive out to the shoulders. A very slight flattening of the tips of the flutes might also occur to assist in spreading the adhesive. If the bonding occurs under these conditions, contraction of the adhesive as it dries and a return to equilibrium of the paper in the flutes would cause a drawing or pulling down of the paper between the flutes.

A washboarding condition can be minimized by the application of less adhesive and by the use of higher solids in the adhesive. The use of clays and diatomaceous earth to build up the solids might be suggested. Reversing the liner has been found to be effective in reducing washboarding on the single face side probably because moisture has less effect on the smooth felt side. This would not be practical on the double backer liner but it suggests the possibility of harder sizing or some wet strength on the inside surface provided the bonding would not be adversely affected.

As I began working on this paper and realized that no concrete information was available, I decided to conduct a quick survey among a number of technical personnel interested in corrugated board production. It is obvious from the many discussions and letters received that there are many rather widely differing opinions held with regard to the causes and corrective measures. I trust, therefore, that the information given will clarify some of the conflicting ideas or, at least, stimulate further thought and discussion at this meeting. My sincere appreciation is extended to those who cooperated by contributing their opinions.

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2. International Critical Tables, Vol. II, 1st ed., page 322, Fig. 2.
3. Killinger, J. E., *Tappi* 34: 36A-42A (April, 1951); *Fiber Containers* 36 (April, 1951).

High-Low Corrugations

F. E. SKIVER

A VERY large part of our truck and rail freight today is packaged in corrugated boxes. To expand the use of corrugated board it has become necessary to establish numerous tests to obtain the quality required to meet consolidated freight classifications.

F. E. SKIVER, American Box Board Co., Grand Rapids, Mich.

Consumers, as well as manufacturers, are interested in these tests to assure delivery of their commodities with a minimum of breakage. Carriers are interested from a claim standpoint.

High-low flutes have been a mutual problem of all corrugated box manufacturers since the establishment of tests which show up the weakness of board containing distorted flutes. Because of the continuous problem of high-low flutes, it is obvious that one cannot make some simple adjustment on his machine and be free from trouble. I would like to discuss the effect of high-low flutes, on tests such as compression, puncture, flat crush adhesion, etc., as well as cover some of the common causes of distorted flutes. Along with this I would like to mention some preventive measures that can be taken.

High-low flutes are recognized as flutes that are irregular or uneven in hight as the web or single face comes off the corrugator. When the single face passes over the double backer glue station, the regular height flutes carry the weight of the hold-down roll and the low flutes, many times, do not come in contact with the adhesive. Consequently, the low spots show up at the cutoff end of the double backer as dry spots or lateral voids. High-low flutes or lateral voids affect both top-to-bottom and end-to-end compression about an equal amount, according to numerous tests made by our laboratory.

Three basic factors to be considered in the manufacture of quality board are: material, machine, and people.

First let us consider materials—particularly corrugating medium.

The corrugating medium must be wound tightly to keep the rolls from flopping with a normal amount of tension. Excessive tension will stretch the sheet and cause irregular flutes, or even cause ruptures.

The 9-point board must be free from foreign materials that might imbed in the corrugating rolls and not permit the paper to fluff evenly.

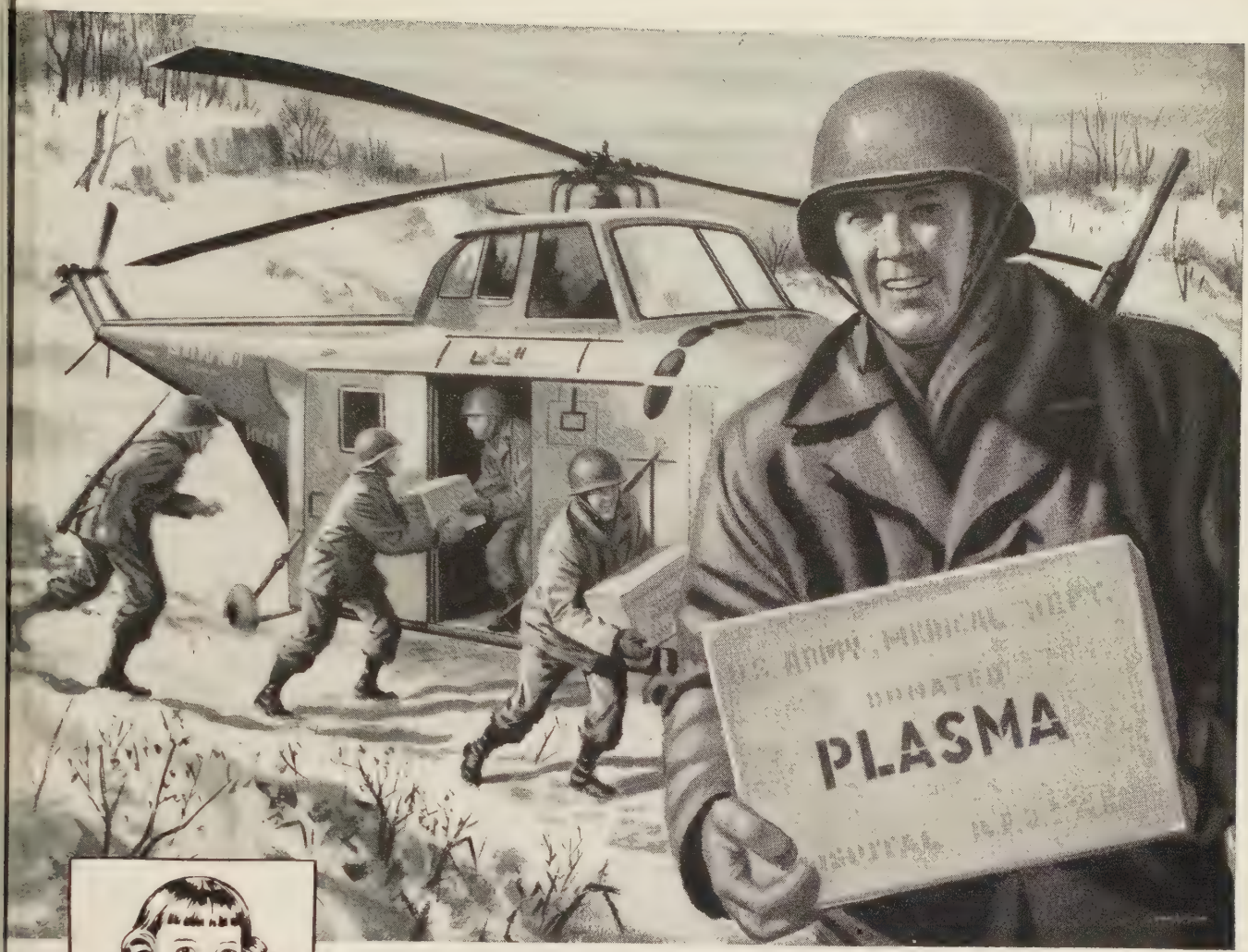
Moisture plays a very important part. If a roll is uneven in moisture content across the sheet, the dry portion must be treated differently than the wet. The wet portion requires very little steam, while the dry part requires a considerable amount to be conditioned properly for fluting. By conditioning, we mean to make the sheet soft and pliable so that it will mold evenly and remain uniform when released from the corrugating rolls. A sheet must be dense enough to make a hard, firm flute, but still not so dense that the steam will not make it pliable.

Next, let us consider the effect the machine has on high-low flutes.

Worn corrugating rolls and inadequate heat are two of the most common causes. Weak compression springs on top of the corrugating roll, worn fingers, bad bearings, and lack of preconditioners also cause high-low flutes. Preconditioners should be serviced with good moist steam to properly condition the sheet at high speeds. Dry, high pressure steam will flow through the sheet and take moisture out rather than make the sheet pliable.

Machine operators play a very important part in the problem. It is possible to have good material and good equipment, but, if not properly used, their value is canceled. Machine operators must be experienced to adjust pressure on corrugating rolls properly to make the paper run evenly into the machine and not rupture the flutes between the rolls. Finger setting is probably the most important function of the operators, and sometimes the most carelessly performed. Fingers must be adjusted so they will allow the paper to fluff out to the glue roll, but still be tight enough to keep the paper from fluttering.

Adjustment of showers is also important to properly condition 9-point at various speeds and to compensate for variation in density and moisture of the sheet. If a sheet is dense, the showers on the preconditioner should be used to a greater extent to give the steam more time to soften the sheet before it is corrugated.



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To summarize, we find that to make quality board a good corrugating medium is essential. It should be wound tightly, with even moisture content, be free from foreign material, and with density such that the sheet can be conditioned properly. Adequate steam must be provided to maintain proper temperature on corrugating rolls, proper roll setting, satisfactory compression springs, good fingers, and proper conditioning devices. Operators must be experienced to know how to adjust the machine for the many variations normally found in materials used to make corrugated board. They should be trained to recognize variations in board runability and in machine operation, to overcome variations, in order to produce the highest quality board.

With these three factors: materials, machines, and operators, carefully balanced the problem of high-low flutes will be minimized.

An Operator Designs a Corrugator

K. W. MAX

At the risk of impracticability it is my purpose to discuss several phases of corrugating technique which, in the interest of uniformity and control, are in dire need of consideration beyond that normally given under the pressure of production requirements. Some of the theoretical aspects of design and operation are also projected on quality and efficiency.

AUXILIARIES

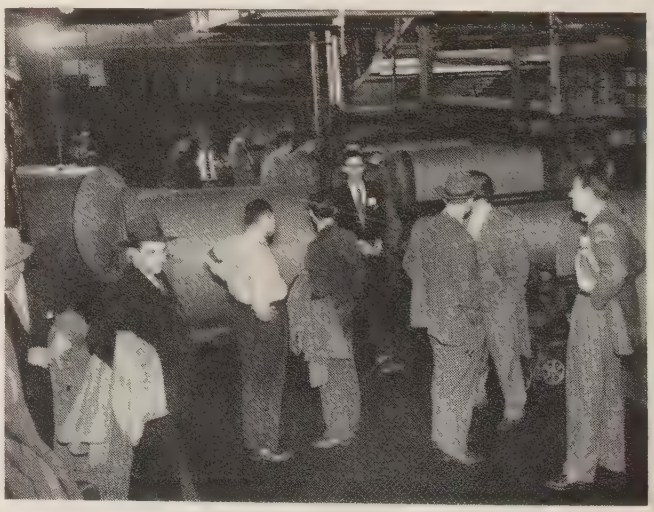
The basic premise of this paper and upon which this industry must found its planning is that there can be no compromise with quality. Each new day we find ourselves faced by more rigorous specifications, narrower control limits, and higher production demands. There need not necessarily be a parable in these demands, even though there is some evidence that the general level of operating skill and experience has suffered under the present condition of labor indifference. As members or parties interested in TAPPI it should be our purpose to make available to the industry suggested improvements in machinery and technique as well as technical and operating data derived by experimentation. The utilization of both mechanical and instrumental auxiliaries may compensate to a large extent a lack of experience in operators. In any case such equipment will serve to improve and stabilize personal judgment. Continued effort will lead to progress in these fields and the ultimate result will be found in an increased exploitation of the potential of both quality and production.

In recent years a number of mechanical and instrumental devices have found new application on the corrugator. Some have been taken from the shelf as integral machines available for numerous fundamental applications, some have been borrowed from related industry and modified, and, still others have been designed specifically for the corrugator. Let us consider several of these. The reverse doctor roll adhesive applicator, a fundamental type of applicator used by the coating industry for many years, has recently proved its worth in corrugating. This apparatus is equally advantageous on most types of adhesives. Hydraulic loading of corrugating rolls, a method used by the paper industry for loading presses and calender stacks for many years, is a new and useful auxiliary. In this connection it seems desirable to study and compare pneumatic methods. Later some experimental data on the relationship of nip pressure and rigidity will be discussed. Instruments such as pressure gages, pyrometers, thermostats, tackometers, etc., have also found use on the corrugator. These auxiliaries, useful in numerous industrial and experimental applications, should be considered as vital as the more indispensable components. The so-called prefeeder for corrugating medium, which is likewise a preheating and tensioning device, is a design made specifically for the corrugator. Its usefulness in preheating and reducing the whip and stress from flat-sided rolls has been established. Other innovations such as shaftless roll stands, roll conveyors, bridge conveyors, liner preheaters with adjustable wrap, etc., have all contributed to efficiency, control, and production. Today the most modern corrugators are incorporating these devices.

DEFINITION OF QUALITY

Before continuing with the discussion of corrugator design and mechanical devices, let us pause and consider the word "quality" which is so vitally fundamental to the original premise. I suppose the practical definition would indicate that quality corrugated board would be that which meets the standards set up empirically by averages and specifications, or that which can be converted into boxes or panels which fulfill adequately the functional or apparent use requirements and specifications. Today this definition is the rule to which most manufacturers set their standards. If I may have your indulgence for a moment, I should rather think of quality corrugated board as that which contains, within narrow uniformity tolerances, the highest proportion of the potential inherent to the components. Under this definition, then, the responsibility for the ultimate level of performance rests with the corrugator rather than the components, whether the latter be good or bad.

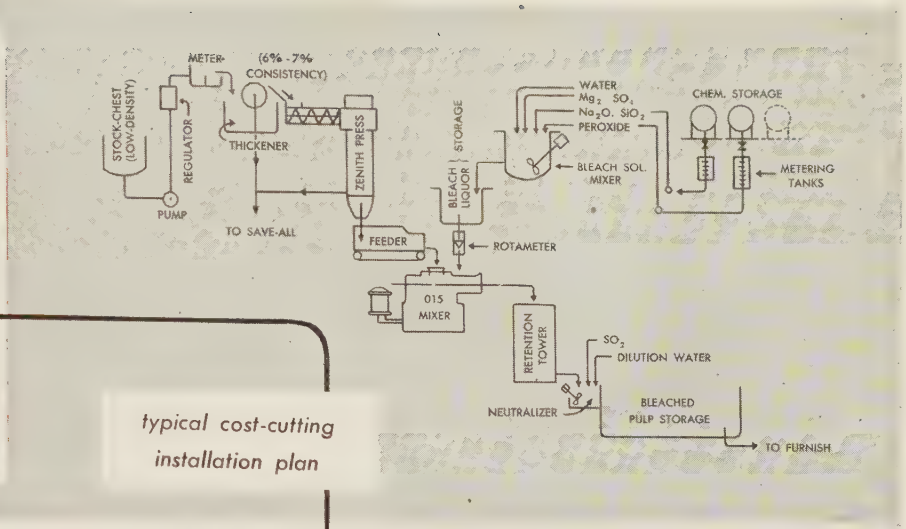
Development of quality as last defined may be exercised by a corrugator only by his handling of the corrugating medium



Corrugator at the Cornell Paperboard Products Co.

K. W. Max, Assistant Technical Director, Robert Gair Co., Inc., New York, N. Y.

Jackson and Church HIGH DENSITY SYSTEM



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From the graph it will be found that at 5% consistency the points brightness increase per point of peroxide is 0.265; and at 40% consistency it is 0.393.

For ten points brightness increase, there will be required, per ton of pulp

@ 5% — $\frac{10}{.265}$ = 38.7 lbs. H_2 O_2 per ton

@ 40% — $\frac{10}{.393}$ = 25.4 lbs. H_2 O_2 per ton

Saving = 13.3 lbs. H_2 O_2 per ton of pulp

Thus for a production of 150 tons per day, assuming 350 working days in the year and a cost of 28½¢ per lb. for H_2 O_2:

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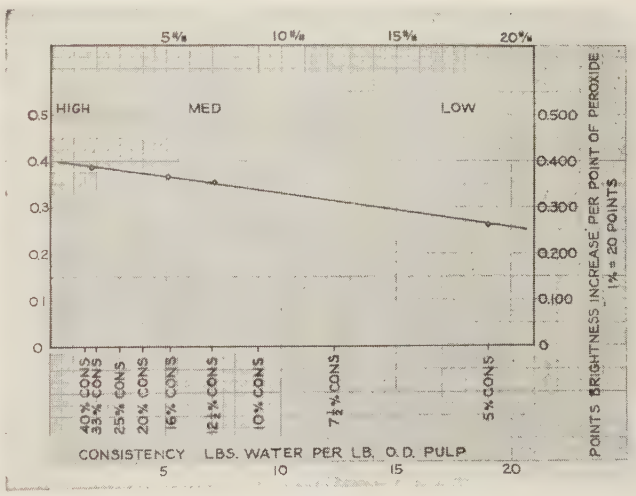

Our engineering department is available for cost analysis

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through the single facer. With the exception of moisture control as it affects curl and adhesiveness, little can be done on the corrugator to modify or improve the characteristics of liner for normal uses. The problem in the latter instance is to hold damage to a minimum.

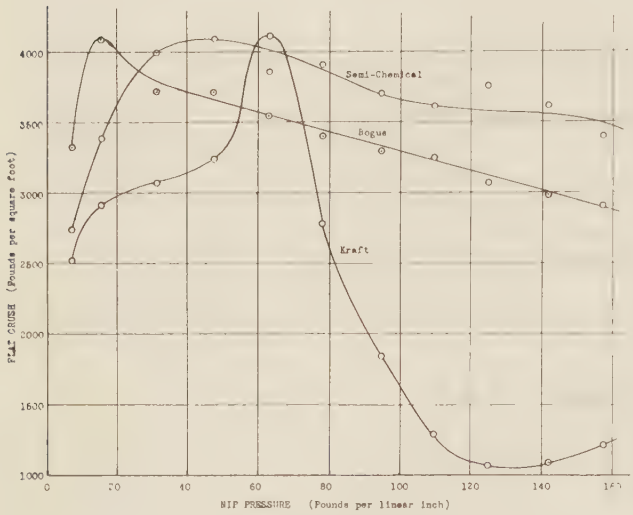

Fig. 1. Flat crush

Worthy of repetition is the fact that quality is made on the single facer. The philosophy of design of the other parts of the corrugator should be based on the idea of efficient performance of the converting task without reducing the level attained by the single facing process.

SINGLE FACER

We should ask ourselves what the primary function of the single facer is. All of us know that the most important purpose is to form a fluted core to support effectively the spacing of two or more plane facings of thin dimensions which, in themselves, would have little rigidity or protective value against impact or load. Naturally the stiffness of this core is of paramount importance, for the structure of corrugated board can be likened to a truss form of architecture where the flexural rigidity of the whole can be correlated to the immobility and moduli of the components. The single facer should develop the maximum of the molded potential of any corrugating medium.

At the mention of the word "molding" it brings to mind a theory I was instrumental in advancing some years ago which outlined the mechanical and thermal forces required to develop the latent physicochemical reactions normal to moldability. It was only after numerous failures to devise a method for evaluating the potential rigidity of corrugating medium that we realized that it was necessary to exert equivalent simultaneous forces of temperature, pressure, and shear to a medium before any estimate of the potential could be attained. These are the forces at work in the nip of corrugating rolls. As many of you know the present-day single flute former, which utilizes two of the three forces indicated above, has found application in evaluating corrugating medium when judiciously used.

There are a number of problems and attendant deficiencies connected with the present-day single facer. Not only do these mechanical shortcomings cause sporadic costly operating cut-backs, but there is an almost continuous defective influence preventing the full realization of quality. Finger marks, bed down of the medium, embryonic fracturing, flutter and improper fluff—all are ever present in varying degrees. There is no need to elaborate on the desperation of high-low flute problems. Insufficient temperature and moisture conditioning of the medium place an undue burden on the ability of this material to absorb about 40% take-up in the one pass formative path through the corrugating nip at speeds up to 500 f.p.m. Molding time at these rates is extremely small. It is the realization of these and many more rather inherent defects of the present design that warrants a careful analysis of the problem and our continuing effort toward better design.

What can be done to improve the seemingly desperate situation? Let us first consider ways to reduce the deficiencies in the present basic design. Finger marks are an inescapable evil attendant to fingers. The degree will depend on the specific circumstance. If we are to eliminate finger marks we must design without fingers. This is, of course, not a simple task, and many efforts have been expended in this cause. It would appear that any further efforts could be thoroughly justified, for the problem of bed down and possibly that of flutter and fluff could be solved at the same time. If you so choose to differentiate, it could be suggested that the unmolded streaks where medium beds down into slots of the top corrugating roll are a source of greater defect than the finger marks. This area forms a natural hinge which can be likened to a score line.

It is doubtful if anyone can offer an attractive design to eliminate fingers at the present time. There is one suggestion that merits some experimental investigation. By periodic treatment of the top corrugating roll with small amounts of a mold release compound, such as one of the silicones, it may be possible to eliminate the stripping function of the fingers and cause the corrugated sheet to follow the bottom roll. In the instance that the sheet adhesion to the bottom roll is insufficient to hug against forces tending to dislodge it, another treatment to the bottom roll with an agent possessing slight adhesive strength might be in order. Elimination of the top roll slots and fingers by any such method presupposes that an adhesive applicator roll of sufficient softness and heat resistance could be designed to ride in contact with the bottom corrugating roll. Problems of flutter and fluff would in this instance be eliminated.

The most likely way that a practical approach to the elimination of finger lines and related defects can be realized is

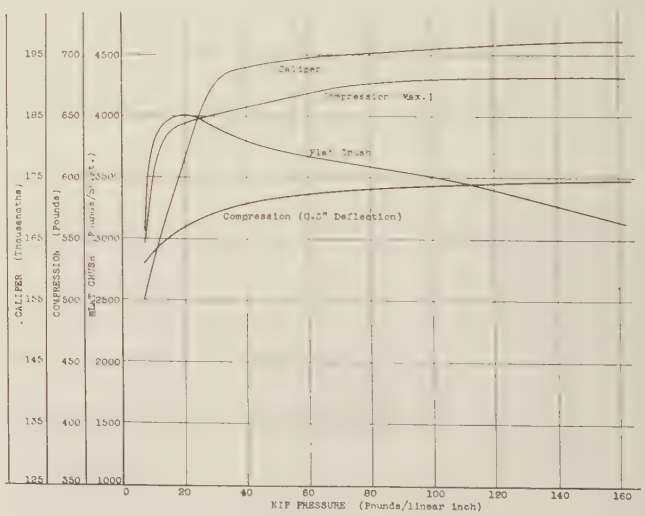

Fig. 2. Bogus

through a fundamental design change. In so doing there are at least two further basic problems to be considered. Increases in molding time and a gentler, more gradual formation of the flutes to the optimum size are requirements which should be built into any new design. Visualize, if you will,

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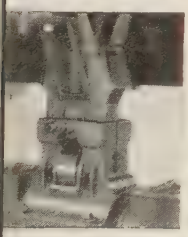

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any combination of large diameter or multiple arrangement rolls to accomplish these ends. The problems involved in improving single facer operation toward the goal of higher quality and efficiency are a challenge to both operators and equipment manufacturers alike.

CONDITIONING

It is possible that the severity of the difficulties outlined for single facer operation could be reduced by careful, controlled conditioning of the corrugating medium. At the moment this approach is one which could yield benefits in little time and at a minimum cost. The role of steam shower conditioners on the medium ahead of the corrugating nip undoubtedly is to plasticize the material in order to prepare for the drastic treatment soon to be encountered. The effect must be to add heat and/or moisture. This being the case, then, a medium of high moisture content which could be elevated in temperature by contact with a hot surface should more than equal any effect produced by steam showering. In order to prepare for low moisture medium it is suggested that provisions be made to apply uniformly controlled amounts of water on the paper surface to be contacted by the hot surface. In this way the water would be forced into the sheet as vapor. If this is done well ahead of the corrugating nip the moisture will have more opportunity to penetrate the interstices of the fiber where the maximum plasticizing effect can be attained. A conventional prefeeder with a water atomizer substituted for the steam shower might be the first step.

While on the subject of the single facer, it is suggested that careful attention be directed to chain drives and the effect sometimes felt on high-low flute formation. Driven speeds of the pressure roll also deserve watching. A helper drive through hydraulic coupling on the top corrugating roll might help reduce fracturing.

BRIDGE

Since the single faced board emerges with the flutes up, it must be reversed in preparation for the double backing operation. Normally a small diameter fly roll is used to direct the single face into the belt elevator to the bridge. It is suggested that this roll be increased in size and removed as

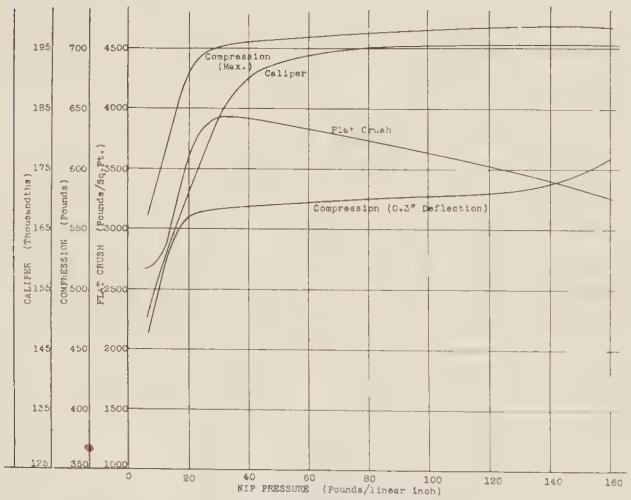

Fig. 3. Semichemical

far as is practical from the pressure roll nip in order to allow more set time of the adhesive and to reduce the angle of flexure in rounding the roll. Observe also the damage done to single face by lacings or wire couplings of the elevator belts. Some case for continuous belts could be built.

Most people agree that substantial damage is inflicted on the single face during its passage through the bridge. Since it is likely that bridge structures will continue in use under present design, long variable speed belt conveyors are imperative, and all surface likely to contact the exposed flute should

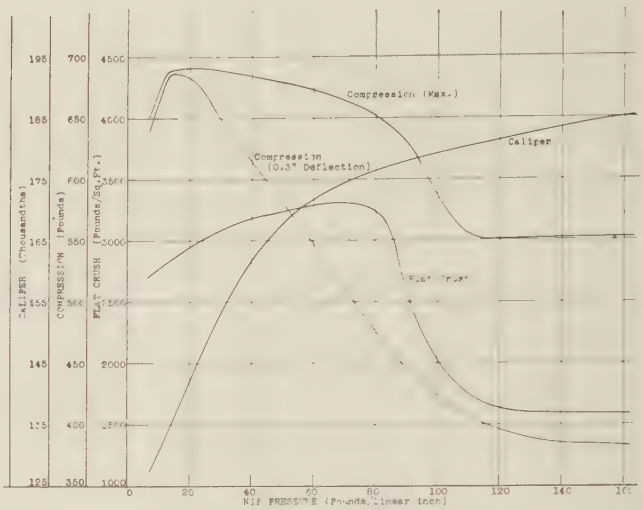

Fig. 4. Kraft

be smooth and nonrestrictive. In operation no excess beyond the minimum needed for splicing and size changing should be carried. Indeed, sincere thought on arrangement permitting straight line operation is in order.

The high moisture content of single face as a result of steaming and adhesive pickup creates a drying problem between the single facer and the double back adhesive station. Preheaters have had limited success because of the harmful effects on the flutes caused by wrapping and sharp bends. It is possible that a conveyerized drying tunnel would serve as an improved substitute for a bridge. Any further curl problems created by an unbalance of heat and/or moisture could be corrected by a preheater-moistener combination on the double back liner. This device could be similar to the suggested apparatus for conditioning corrugating medium.

DOUBLE BACKER

At the time the single face reaches the double back adhesive applicator, which also should utilize the reverse doctor roll principle, another degrading operation is encountered. The heavy solid steel rider roll is capable of crushing or tilting the flutes. Unless proper settings of the spacer screws are vigilantly maintained there can occur either flute damage or improper adhesive application. It is suggested that this rider roll be fabricated of lightweight tubular design which can be loaded to a degree consistent with individual requirements by a double action pneumatic or hydraulic loading device. This can be made automatic by electrical controls.

When properly prepared single face and back liner are joined at the hot plate section, the bond or the molded core structure should not be disturbed. Since the moisture content during this final phase of the combining operation is exceedingly high, the physical resistance to abuse is low. Reflect if you will on the possible damage drier belt seams and heavy rider rolls can inflict on the soft wet board.

It is the usual case that this wet, tender condition continues to exist throughout the hot plate section, the so-called cooling section, the slitter, and the cutoff. Considering the many potential deteriorating hazards to be met during this path, I propose that more positive measures be taken to insure that trapped moisture be removed, thus allowing the board to

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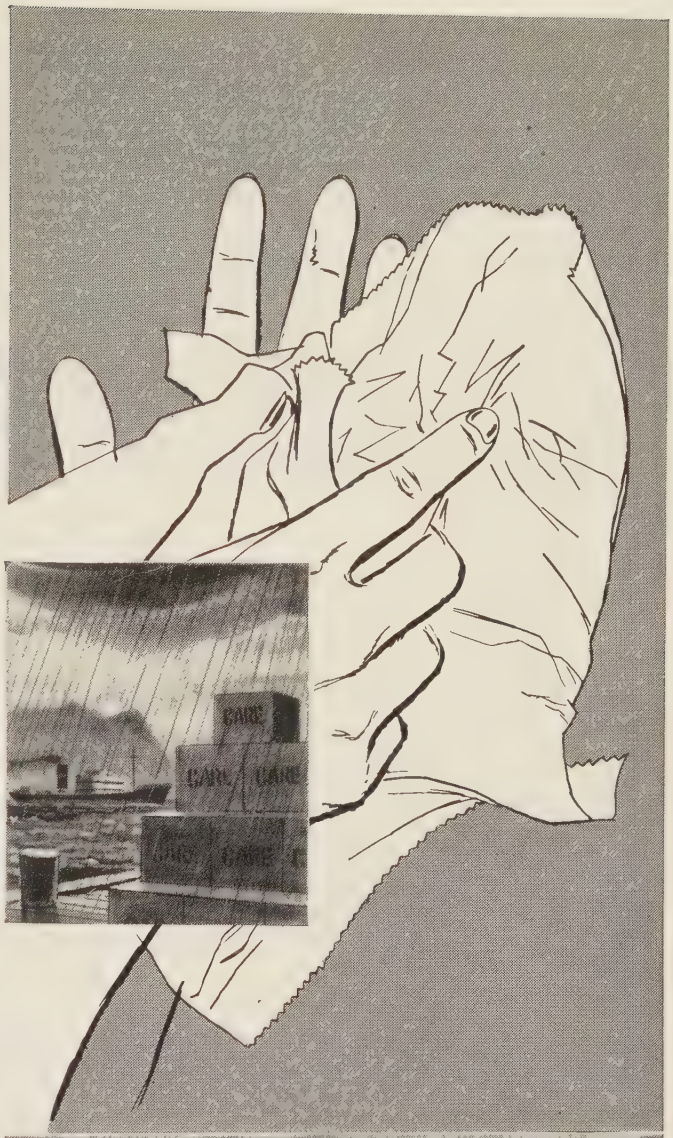

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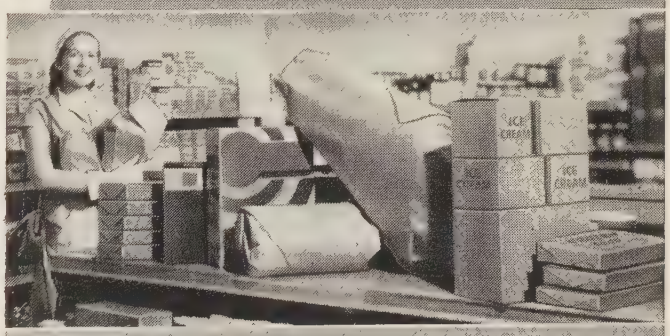

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assume a more resistant condition. I suggest that a system be designed wherein a suction blower draw a stream of heated air in and out of the flute passageways through adjustable retractable slit nozzles.

NIP LOADING TESTS

It was my contention that quality corrugated board was developed on the single facer. We have recently completed a series of experiments on our laboratory corrugator in which the relationship of rigidity and corrugating roll nip pressure was studied. The following results may illustrate the critical nature of that one variable in producing the maximum desired result. Although these A flute relationships were determined at very low speeds due to limitations of the physical features of the laboratory corrugating machine, most of the other controllable variables were maintained constant. The following graphical illustrations will review the data for three corrugating media—bogus, semichemical, and kraft—all of which were available but not necessarily representative of general type.

In Fig. 1 the relationship of flat crush to corrugating roll nip pressure for three media is shown graphically. Speed was 100 f.p.m.; steam pressure was 155 p.s.i.; roll diameter was 8 in. top and bottom; tension and steam showering was unmeasured but constant, adhesive was standard Stein Hall-type starch.

Flat crush maxima for various media occur at different loading pressures. In general the maximum occurs at relatively low nip pressure and thereafter declines. The extreme peak for kraft is not easily explained but the rapid decline after 62 lb. per linear in. is a result of fracturing under the conditions of the run. It is considered coincidental that the maximum is about the same value for each medium. Although the data are not shown the maximum flat crush for each medium was attained at pressures considerably lower than are required for maximum caliper.

The data illustrated in Figs. 2, 3, and 4 were obtained for the same components and under the same conditions as those of Fig. 1 except that 130 f.p.m. was the operating speed. In this instance caliper and compression relationships were also studied. Specimens for compression were composed of 8 by 8 by 8-in. sleeves with 1-in. partial flaps with mitered corners.

Both semichemical and bogus media showed similar relationships to nip pressure when rigidity and caliper were measured. Again flat crush maxima occur at different loading, and the decline at high pressure is evident. It is interesting to note that compression parallels caliper to a remarkable degree at maximum level. These maxima do not correspond to those of flat crush.

The data for kraft in Fig. 4 are less significant because of the fracturing which occurred at nip pressures above 70 to 80 lb. per linear in. of face. The steep slope of both flat crush and compression curves beyond this critical pressure is obvious even though caliper continues to rise.

Although the data of these curves have been determined on experimental equipment outside the range of conditions normally used commercially, they will serve to emphasize the critical nature of any medium in responding to corrugation. It would appear that optimum quality is restricted to a limited range in any combination of operating variables.

INSTRUMENTATION

It is my hope that individual plants may sometime equip themselves to carry out experiments of the nature just illustrated so that similar data may be derived on a commercial basis. Moreover, other variables such as tension, temperature, speed, conditioning, flute size and shape, etc., could be systematically studied until a reasonable range of optimum conditions could be established for each particular circumstance.

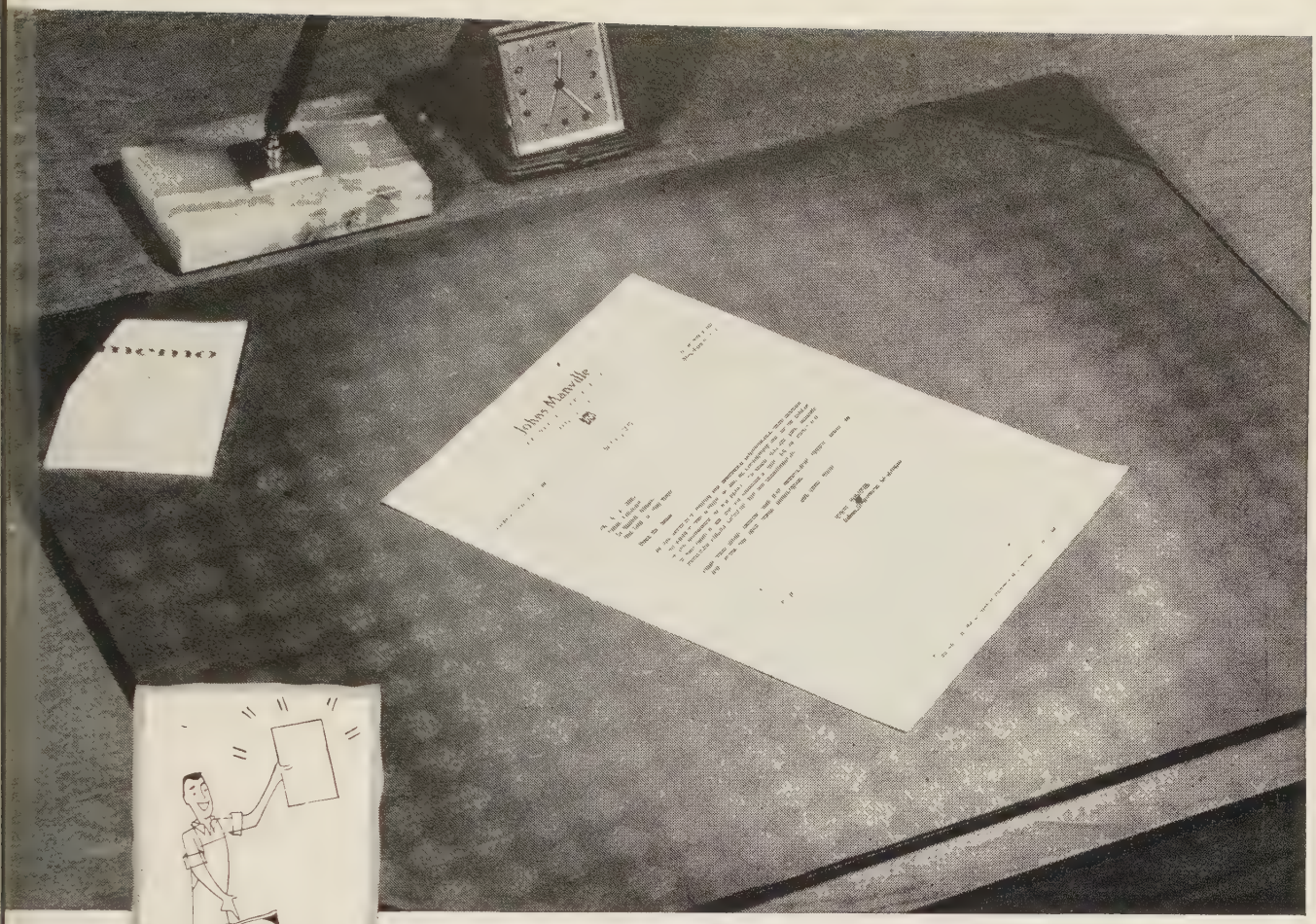
In order to accomplish this tedious task complete instrumentation and automatic auxiliaries would be required. This equipment is, however, most desirable in any instance. Instrumental and automatic mechanical devices will lend the utmost toward the stabilization of an operator's personal judgment.

It is suggested that a corrugator operator be furnished with an integrated centralized panel of indicating and recording instruments near his operating station to spell out in permanent record the general condition of his machine. Among these instruments the following would be useful: roll speed, paper speed, temperatures of critical components, steam flow, roll loading pressures, temperature and viscosity of adhesive, water flow, and front, middle, and back caliper of the finished board.

I should like to expand on the usefulness of a continuous caliper measurement. Such a measurement can be a significant guide to over-all control. A number of defects can be reflected by caliper changes, general or localized. Poor formation, damage, cross machine variation, etc., can be detected in little time when almost instantaneous indication is available.

SUMMARY

Throughout this paper I have attempted to point out several weak phases of present-day corrugator design and technique. In some instances I have suggested an approach to an improved design. Some of these are undoubtedly unsound or impractical. If so, I hope that sufficient provocation has been offered to prompt concerted effort toward the genuine solution. In attacking the deficiencies as we now recognize them, I am convinced that we can make progress in lifting the corrugating process from its present "rule of thumb" state to an operation of considerable precision.



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FOR THE PAPER INDUSTRY

Registration of Professional Engineers

Ed. Note: The following article was prepared for *Your Consultant*, the official periodical published by the Association of Consulting Chemists and Chemical Engineers, Inc., 50 East 41st St., New York, N. Y., by Newell L. Freeman, Secretary, Board of Examiners of Professional Engineers and Land Surveyors, the University of the State of New York, the State Education Department, Albany, N. Y. A subject of great importance to the profession as well as the public, it still causes much confusion owing to lack of general information. *Tappi* appreciates the courtesy of the Editor of *Your Consultant* in extending permission to republish this excellent information regarding professional engineers' registration. Inquirie srelating to this subject have been received many times by the Secretary of TAPPI.

Most engineers are so consecrated to their profession that they desire to know more concerning the statutory requirements for registration (or licensure). Also, many would like to understand better the advantages accruing therefrom. This article endeavors to shed some light on the subject of registration and to provide a general guide to those who wish to make application.

Registration began in Wyoming in 1907 when it was found necessary to regulate by law the practice of engineering in connection with the vast irrigation program in that state. New York adopted a statute of this nature in 1920. In 1927 engineering and the other learned professions (with the exception of law) were incorporated in the State Education Law and, thereafter, they have been administered by the Commissioner of Education. The extent to which engineering falls within the purview of the statute is shown in the following excerpts from the New York State Education Law:

> A person practices professional engineering. . .who holds himself out as able to perform or who does perform any professional service, such as consultation, investigation, evaluation, planning, design, or responsible supervision of construction or operation, in connection with any public or private utilities, structures, buildings, machines equipment, processes, works, or projects, wherein the safeguarding of life, health, or property is concerned or involved, when such professional service requires the application of engineering principles and data.
>
> "It shall be unlawful for any person to practice or to offer to practice professional engineering. . .in this state or to use the title engineer. . .or any other title, sign, card, or device in such manner as to tend to convey the impression that such person is practicing professional engineering. . .or is a professional engineer. . .unless such person is duly licensed under the provisions of this article."

In this manner the people of New York have placed engineering in the group of professions which may be practiced only by those who have satisfactorily qualified according to the statute. Automatically there arises the question, "Why have New York and other states done this?" The answer is, "For the protection of the public." Only in this manner is it assured of competence among those who offer to practice engineering.

Although engineering is a profession as old as civilization, the advent of registration (or licensure) by the state as a statutory requirement is comparatively recent. At the beginning of the twentieth century, the public's attention was drawn to matters related to engineering by various tragic events resulting from faulty planning and design. Many of these disasters involved structures so this was recognized in the first legislation on engineering. With the enormous development and expansion of engineering which is still in progress, most registration laws now include all branches of the profession.

Since the registration of engineers is for the protection of the public, the public must be the first consideration while the profession and the individuals in it must rank second. The public is interested in protecting itself from the incompetent and the unprincipled ones who seek to prey upon it in the name of engineering. It wants an available supply of dependable engineers. The public is not particularly concerned about providing a better way of life for engineers except as it serves the public's interests.

Certain considerations characterize the registration laws adopted by almost every state. The most important of them is that only those who have satisfied the requirements prescribed by law may register as professional engineers while the profession has been given the responsibility of saying whether or not applicants have met the requirements. The basic philosophy is essentially that, for the protection of the public, the exclusive right to practice in the field of engineering has been given to those who satisfy the legally prescribed qualification requirements. The profession has the task of determining what the exact requirements are and when they have been satisfied. This recognizes the value of the time-honored custom whereby the qualifications of learned men are judged by others of similar learning who have already established their qualifications. Thus, beyond a general outline in the law of what the public requires, the profession is expected to administer itself and is given this right of self-preparation and self-determination. The profession determines what constitutes adequate education and experience and, through Board action, authorizes an applicant to practice only when he is considered to be qualified.

Not only does this serve the best interests of the public but it also places an obligation upon those engaged in engineering. As good citizens, it is incumbent upon each to respond to the spirit as well as the letter of the law. Even now, many regard this duty with apathy and fail to realize that professional practice carries with it a special form of citizenship and a preferred position in society. These should combine engineers into a group with common interests which are above and beyond the limited responsibilities of technicians.

In each state there are certain statutory qualification requirements and the application forms are designed around them and arranged to include whatever additional information the Board believes necessary for its considerations. The applicant is required to make affidavit concerning the truth of the statements contained in the completed form.

PROCEDURE

1. Obtain the required forms, instructions and a list of the qualification requirements. Sometimes these are available through engineering society local offices but the Board secretary is always in a position to supply them.

2. Execute the application form (or forms) according to instructions being careful to supply all the requested information.

3. Describe experience accurately and concisely so that for each engagement the Board will know the title under which you worked, your employer, and location and what you did while so employed. If you want to submit greater detail, do so in a separate, supplemental description.

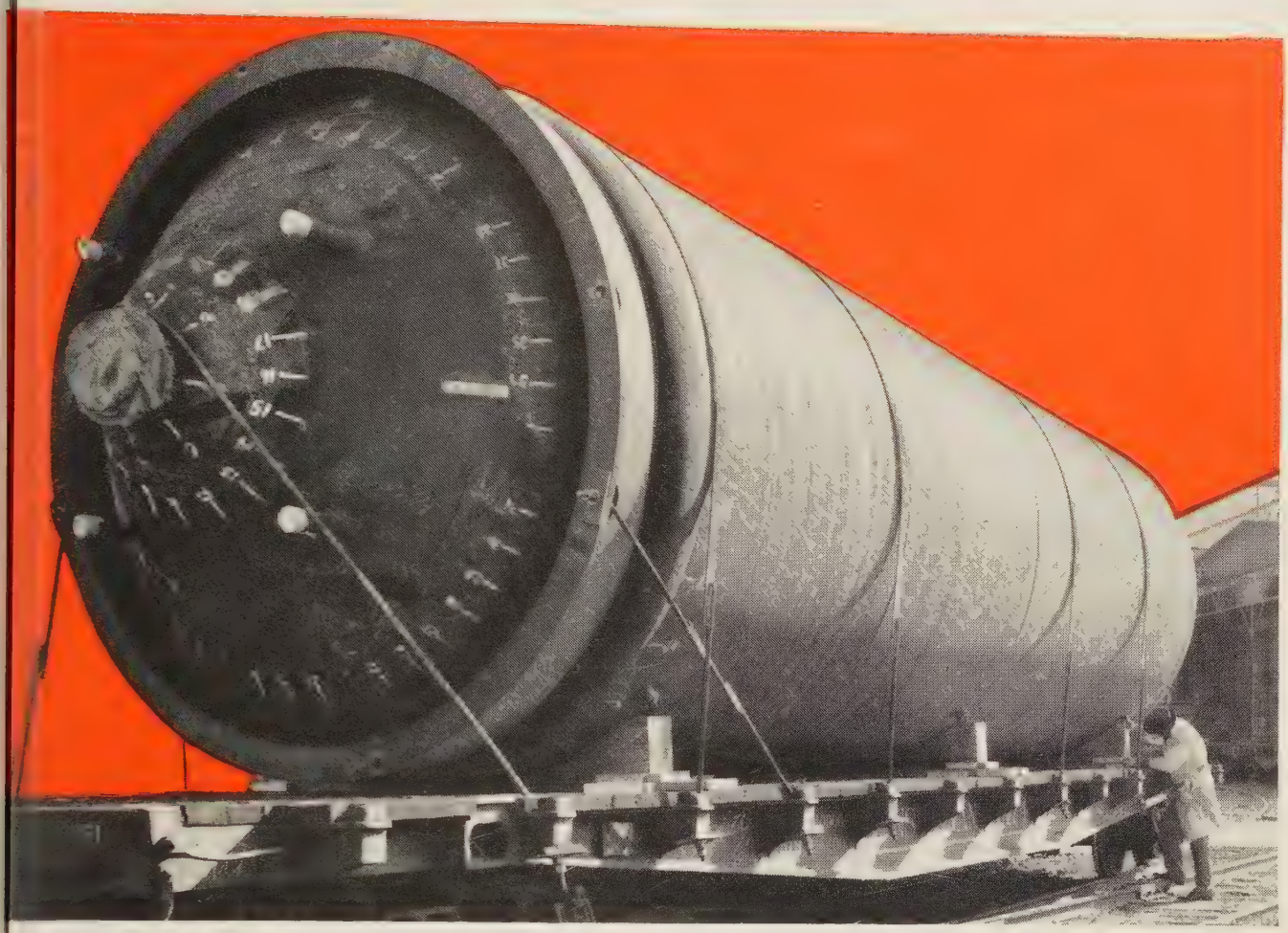
4. In supplying reference names (or endorsements, if required) select those upon whom you can depend to give accurate replies to the Board.

5. Mail to the secretary your completed application, the required fee, and whatever supporting documents are specified in the instructions.

THE APPLICATION

Generally the name of the applicant is the first required information. This should be your legal name. If there has been a change made in it by court order so that some of your training or experience appears under a different name, a copy of the court order should be made available to the Board in order to clarify the matter.

Twenty-seven states and territories leave the question of maturity to the judgment of the Board while thirteen of them require the applicant to be at least 21 years old. Another places the minimum at 24 years and ten say he must be at least 25 years of age. Thus the date of birth is always asked



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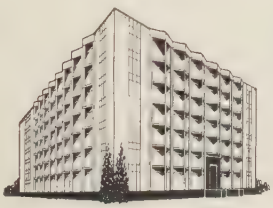

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and frequently the place as well. Sometimes a Board requires this to be verified by a copy of the birth certificate. In eleven states requiring citizenship or a legal declaration of intention to become one, a foreign born applicant may be required to send in his original papers or those of the parent from which his status is derived. Of the eleven, two states accept Canadian as well as United States citizens, seven require citizenship or a legal declaration of intention while two expect a fully established status. Documents of this nature are irreplaceable and it is suggested that they be withheld by the applicant until officially instructed to submit them. Then they should either be sent by registered mail or personally taken to the authorities.

Not all qualification requirements are specified in the law of each state. However, good and moral character is one which appears in forty-seven statutes while the remaining four leave it to the discretion of the Board. In general, the methods by which character is established are by references although the procedures vary considerably among the different Boards. All require an affidavit with the application and, in addition, by various methods, obtain statements from the references. Some require reference endorsements by licensed professional engineers. The judgement of professional engineers regarding the character and degree of responsibility in engineering work is preferred.

Forty-eight statutes require graduation from a recognized engineering course or the equivalent in training and experience. Almost all have examination provisions with varying degrees of Board discretion in their usage. Most of them permit the Board to accept many years of experience as having demonstrated those qualifications for which validation is sought by written examinations. However, some go further and require, in addition, that the applicant show that he has attained recognized standing in the engineering profession if he is to receive favorable consideration because of his long experience. Such provisions are not to be confused with "Grandfather Clauses" which are those whereby applicants who successfully show that they have had a prescribed number of years of engineering experience are automatically registered. A "Grandfather Clause" is an essential ingredient in the initial phases of registering in a profession and is usually removed from the law after the first few years. Thus, almost none of the current engineering laws has one which is now effective.

In adopting registration statutes most states and territories have felt that an applicant should have practical experience in engineering before he could be expected to practice safely and dependably and, for this reason, have made experience a statutory qualification requirement. This experience must be of a grade and character satisfactory to the Board. The acceptability of it may vary between the states. The New York Board believes that a graduate can obtain satisfactory experience only in a position or positions for which a technical education is a prerequisite. While few go into positions of responsibility immediately upon graduation, the succeeding years should show a marked advancement toward greater responsibility. Experience descriptions should make clear the applicant's progress in this regard.

EXAMINATIONS

Many states now require applicants to pass written examinations as part of the qualification requirements in engineering. While most Boards may accept many years of outstanding achievement as adequate evidence of qualification, few engineers can afford to wait so long or to gamble that a Board will eventually rule that their experience records satisfactorily demonstrate qualification. It is not advisable to encourage them to delay in hopes of avoiding examinations. While the value of examinations as a measure of engineering qualifications is always debatable, they are often the Board's only recourse.

Examinations are usually constructed to test first the technical training of the candidate, while succeeding questions require also the use of engineering judgment and rely upon his experience for satisfactory answers. Many, but not all, are of the "open book" type.

In preparing for examinations the candidate should find out their length and scope as well as the circumstances under which they are to be given. Most engineers work in rather narrow fields and before taking examinations should do some reviewing in the subjects used less frequently.

Refresher courses are offered in many parts of the country to assist in this matter. In addition, the candidate should allot the allowed time for an examination in order to be able to answer enough questions to earn a passing mark.

Half of the states have a provision to facilitate the taking of examinations by giving part of them immediately after graduation when technical training is fresh in the minds of graduates. These are called the preliminary examinations and those who pass them become engineers-in-training. After these men accumulate enough satisfactory experience they are eligible to take the remainder or final examination. This procedure is recommended to all recent graduates both for its convenience and because those taking the examinations in this manner achieve a higher degree of success than those who wait until they are eligible to take all of them at once.

An engineer who earns his registration by passing written examinations in one state is in a much stronger position when he seeks a license in another based upon the one he possesses. This kind of record is much more acceptable to all Boards of Engineering Examiners than any other.

The following addresses of Registration Boards are listed in "Legal Registration or Licensing of Professional Engineers" December, 1950, pages 5 to 8, published by National Council of State Boards of Engineering Examiners.

Alabama State Board of Registration for Professional Engineers and Land Surveyors
Clifton C. Cobb, Executive Secretary
702 Washington Ave., Montgomery 5, Ala.

Alaska Board of Engineers and Architects Examiners
Linn A. Forest, Secretary
Box 251, Juneau, Alaska

Arizona State Board of Technical Registration
Lewis S. Neeb, Secretary
P.O. Box 1029, Phoenix, Ariz.

Arkansas State Board of Registration for Professional Engineers
V. E. Scott, Secretary
P. O. Box 175, Pulaski Heights Station, Little Rock, Ark.

California State Board of Registration for Civil and Professional Engineers
W. A. White, Executive Secretary
529 Business and Professions Bldg., 1020 N. St., Sacramento 15, Calif.

Colorado State Board of Examiners for Engineers and Land Surveyors
W. T. Blight, Assistant Secretary
20 Capitol Bldg., Denver, Colo.

Connecticut State Board of Registration for Professional Engineers and Land Surveyors
William K. Simpson, Secretary
30 Oak St., Hartford 6, Conn.

Delaware State Board of Registration for Professional Engineers and Land Surveyors
Thomas J. McDonnell, Secretary
P.O. Box 1266, Wilmington, Del.

Florida State Board of Engineer Examiners
Mrs. Ann P. Clover, Executive Secretary
702 John F. Seagle Bldg., Gainesville, Fla.

Georgia State Board of Registration for Professional Engineers and Surveyors
R. C. Coleman, Joint Secretary
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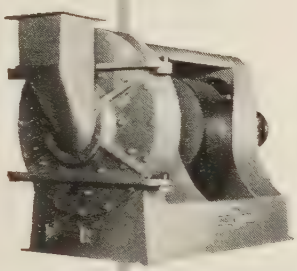

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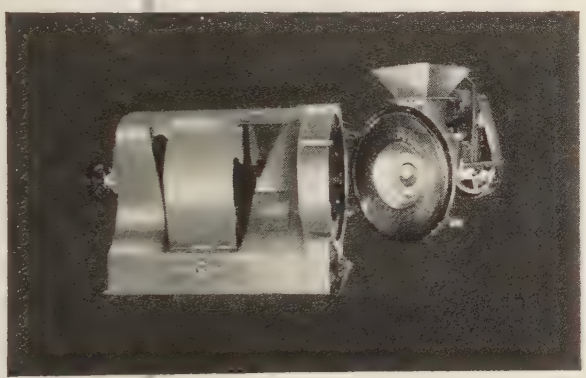

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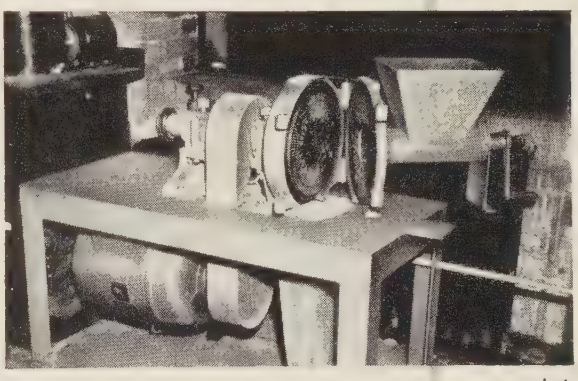

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230 State Capitol, Indianapolis, Ind.

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State Capitol Bldg., Des Moines 19, Iowa

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H. E. Bullock, Assistant to Secretary
Suite 7, Majestic Bldg., Topeka, Kan.

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University of Kentucky, Lexington, 29, Ky.

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Civil Engineering, Bldg., Tulane University
New Orleans 18, La.

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Bangs Station, Waterville, Me.

Maryland State Board of Registration for Professional Engineers and Land Surveyors
J. W. Gore, Secretary
1101 Key Highway, Baltimore 30, Md.

Massachusetts State Board of Registration of Professional Engineers and of Land Surveyors
Albert Haertlein, Secretary
Room 34, State House, Boston, Mass.

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State College, Raleigh, N. C.

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Miss Rebecca J. Nickles, Secretary
324 Education Bldg., Harrisburg, Pa.

Puerto Rico Board of Examiners of Engineers, Architects and Surveyors
Luis Cueto Coll, Secretary
P.O. Box 3717, Santurce, Puerto Rico

Rhode Island State Board of Registration for Professional Engineers and Land Surveyors
Philip S. Mancini, Secretary
242 State Office Bldg., Providence, R. I.

South Carolina State Board of Engineering Examiners
T. Keith Legare, Secretary
P.O. Drawer 1404, Columbia, S. C.

Wisconsin State Registration Board of Architects and Professional Engineers
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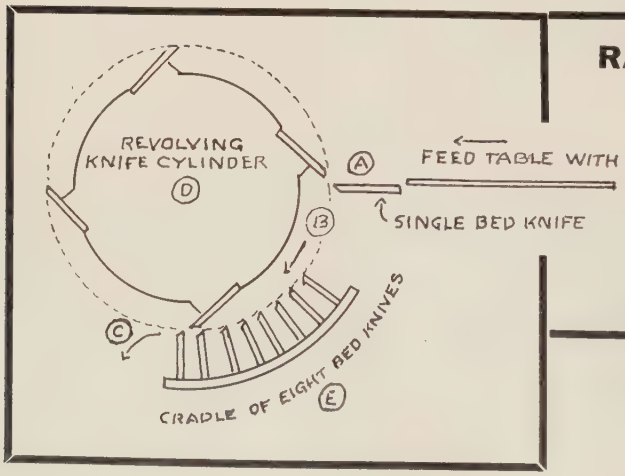
312 South, State Capitol, Madison 2, Wis.

Wyoming State Board of Examining Engineers
Miss Wilma Hageman, Assistant Secretary
201 State Capitol Bldg., Cheyenne, Wyo.



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Concepts of Quality Control

W. R. PURCELL

Statistical quality control in the pulp and paper industry is the common ground between the Statistics Committee of TAPPI and the American Society for Quality Control. Knowledge of problems encountered by the latter is of value to the former. One important problem is lack of mutual understanding within supervisory and technical staffs. To promote such understanding, various concepts of quality control are discussed. The concepts relate to procedures in setting tolerances, sampling for inspection, making acceptance and rejection decisions, using inspection data to control processes, analyzing process data, and planning and executing experiments. The mutual understanding provided by these concepts is vital, for success in quality control depends on coordinated effort.

THE Statistics Committee of TAPPI is concerned with the application of statistical methods to various functions in the manufacture of pulp and paper, including quality control. The American Society for Quality Control, on the other hand, is concerned with the control of quality by various means, including statistical methods. The two societies meet on common ground in the development of statistical quality control in the pulp and paper industry. It is in this common ground that the Statistics Committee has found its logical starting point.

In most of its contacts with quality control, the Statistics Committee has heard only about successful applications. This is natural, for progress in quality control has been substantial during the past decade. Yet this progress has not been without its problems. If TAPPI is to gain maximum benefit from the experience of ASQC, it should also know about the problems and the apparent reasons for them.

One important problem in many cases is lack of mutual understanding at the supervisory and technical level. Because a number of managers, engineers, technicians, superintendents, etc., have been exposed to courses in statistical quality control, there are developing, within the staffs of many organizations, two separate groups. One group has accepted the philosophy of statistics; the other group has not. One group is anxious to install control charts; the other is not. One group sets up scientific sampling plans; the other group has no objection to this, but wants to use "judgment" when the use of a plan results in rejection. One group wants to plan and execute experiments soundly; the other group agrees in principle, but then says "not this time." This divergence of viewpoint can severely hamper the progress of a quality control program.

One important reason for this divergence is failure to distinguish between statistical quality control and general quality control, to place each one in its proper perspective, to understand their interrelations, and to clarify their basic concepts.

W. R. PURCELL, Quality Control Manager, Brown Co., Berlin, N. H.

General quality control existed for years before statistical methods were introduced. In general quality control there were many standard procedures. Tolerances were specified. Raw materials, work in process, and finished products were inspected and sometimes rejected. Data from these inspections were used to determine what process adjustments should be made to control product uniformity. Process data were "analyzed" to determine cause-and-effect relationships. Experiments were run to "find out for sure" about such relationships. None of these procedures is new.

But the procedures for doing these things were poorly defined. Quality control depended almost entirely on experience, judgment, and know-how. While much progress was made with this rough-and-ready approach, there were also many costly wrong decisions.

What does statistical quality control do? It defines the procedures, in order to minimize the costly wrong decisions. It is at this point that the reason for the divergence of viewpoint becomes apparent. It is in the answer to the question: Will well-defined procedures help in the problems of setting tolerances, sampling for inspection, making acceptance and rejection decisions, using inspection data to control processes, analyzing data, planning and executing experiments?

To reach agreement on this question the following concepts have been found useful.

CONCEPT 1: ECONOMIC QUALITY BALANCE

Unsatisfactory quality in material, work in process, or finished products is costly. It causes scrap, rework, increased costs in subsequent processing, decreased price, complaint costs, replacement costs, loss of good will, or some combination of these. On the other hand, the more exacting the quality level, the greater the manufacturing costs become; beyond a certain point the increase in manufacturing cost is greater than the increase in value of the product.

The setting of quality standards is an attempt to arrive at the economic quality balance between these cost extremes. This should be recognized by all who have quality authority and responsibility. Once this is clearly and mutually understood, differences in viewpoint on the matter indicate the need for new facts or better analysis of known facts.

CONCEPT 2: THE ULTIMATE JUDGE

The ultimate judge of quality is the customer. This is not always kept in mind.

The point is illustrated by the case of product X. Characteristics A and B were carefully tested and expensively controlled. In a market quality survey, persons were asked to use competitive samples of the product, to state which brand they preferred, and why. The majority named characteristic C as the most

important one. Characteristic C was not even measured, let alone controlled. But the routines had become firmly established. When the reaction indicated by the survey was pointed out, the comment was: "People don't know what is important in product X, do they?"

CONCEPT 3: THE MEANING OF TOLERANCES

In industries in which the product is made in individual units, tolerances for the characteristics of the units are well defined, and there is usually little confusion on this point. In such industries today it is also realized that, when inspection is done by sampling, tolerances for the aggregate of product, i.e., the allowable proportion of nonconforming units, must also be specified. Much progress is being made on this problem.

In the batch and continuous industries, such as pulp and paper, it appears that many tolerances are not yet well defined. For instance, if basis weight limits for paper are stated as 38–42, just what does this mean? Does it mean that the average of a shipment must be within those limits? Does it mean the average basis weight of each roll in the shipment? If so, how is the roll to be sampled to determine its average basis weight? Does it mean that each square foot, square yard, etc., of paper must be within limits?

The pulp and paper industry has much to do in spelling out the meaning of tolerances more explicitly.

CONCEPT 4: ACCEPTANCE LIMITS VERSUS CONTROL LIMITS

In establishing tolerances, a distinction should be made between acceptance limits and control limits. Acceptance limits are established for product acceptance; control limits are established for process control. Acceptance limits are based on customer requirements, market quality, etc.; control limits are based on how well the process can do. Usually the two kinds of limits are not the same. But the relation between them is of great importance in finding the economic quality balance. In general, there are three situations:

1. *Acceptance limits appreciably wider than control limits.* This is the ideal situation. Reasonably good process control results in complete customer satisfaction with a minimum of scrap, rework, and sorting.

2. *Acceptance limits at or near control limits.* This is a tight situation. Complete customer satisfaction can be retained only by very close process control, unless there is some scrap, rework, or sorting.

3. *Acceptance limits narrower than control limits.* In this situation, scrap, rework, and/or sorting are necessary to assure customer satisfaction. When this is so, constant effort should be applied to make fundamental process improvements, get the customer to relax his requirements, or both.

Failure to distinguish between acceptance limits and control limits has caused much costly confusion.

CONCEPT 5: CRITERIA VERSUS JUDGMENT

In general quality control, when product acceptance is done by sampling inspection, the implied inference is that the quality of the lot is nearly the same as the quality of the sample. Based on that inference, the acceptability of the lot then becomes a matter of judgment.

In statistical quality control it is recognized that the inference of equality of lot and sample is not justified. Instead, a long-term judgment of acceptable and rejectable quality levels is made, and a balance is found between risks of wrong decisions and cost of inspection. As a result of this long-term judgment, specific criteria are established for acceptance and rejection of individual lots.

Occasionally, however, even with an established acceptance sampling plan, there is the temptation to use judgment instead of the criteria on individual lots.

The sample from the particular lot in question simply does not provide the facts needed for further "judgment." The only logical place to apply judgment in such a case is in a review of the whole acceptance sampling plan.

CONCEPT 6: BURDEN OF PROOF

In many modern acceptance sampling plans, the efficiency of the system is improved by using quality history to supplement the data from the isolated lot. If the quality history is good, liberal acceptance criteria are allowed; if the history is poor, strict acceptance criteria are required. This procedure reduces inspection cost.

With these plans, however, the call for "judgment" (usually in case of rejection on strict criteria) is even more emphatic. A valuable concept in this situation is one borrowed from the law: *Burden of Proof.* If quality history is good, the presumption is that the lot is good, and the burden on the sampling is to prove that it is bad. If quality history is bad, the presumption is that the lot is bad, and the burden on the sampling is to prove that it is good.

CONCEPT 7: ACCEPTANCE SAMPLING VERSUS CONTROL SAMPLING

The method of sampling to be adopted in any case depends on whether the primary purpose of the sampling inspection is to appraise the product or to control the process.

If the primary purpose is to appraise the product, the objective is to minimize the likelihood of large differences between quality of sample and quality of lot. This is done by acceptance sampling, in which the sample is drawn in as nearly *random* fashion as practicable, i.e., in such a way that any part of the lot is as likely to be sampled as any other part.

If the primary purpose is to control the process, a *nonrandom* type of sampling, called control sampling, is used. The objective in this case is not to appraise the product, but to compare the *variability* of the process with its *capability.* The variability is generally indicated by differences *between* samplings, the capability is indicated by differences *within* samplings. To derive the maximum benefit from control sampling, the sampling is done in such a way that the differences *between* samples are *maximized* and the differences *within* samples are *minimized.*

CONCEPT 8: FUNDAMENTAL PROCESS CONTROL

In order to control his process, an operator must at

ll times have available the answers to the questions f fundamental process control:

1. Is the process in need of adjustment?
   (a) If not, he must leave the process alone.
   (b) If so:
2. When should an adjustment be made?
3. What should be adjusted?
4. In what direction should it be adjusted?
5. How far should it be adjusted?

The more the answers to these questions are based n hunch, the less effective the process control. The re the answers are based on facts as told by the ocess, the more effective the process control.

CONCEPT 9: PROCESS CAPABILITY

In any process there is an extremely large number f causes which are constantly producing variability the product. If the effect of each cause is small com- ed to the combined effects of all the rest, the process statistically stable. If one or more dominant uses is present, however, statistical stability is lost, d can be restored only by eliminating the dominant use or causes.

When variability *within* control samplings has been imized and there is evidence that it is random, that iability is due to a large number of small causes. represents the variability which is inherent in the ess. The limits of such variability are called rocess capability.

The fundamental process control question: "Is e process in need of adjustment?" can be answered undly only if the capability of the process is known

CONCEPT 10: REASONING FROM SAMPLE TO PROCESS TO PRODUCT

In most cases of control sampling, the differences tween samplings which are beyond process capability nits are due to changes in the process which occur from me to time. The purpose of the sampling is to dicate whether such changes have taken place. If anges do take place between samplings, the sampling elds a poor appraisal of the product, for the sampling nonrandom.

If, however, successive samplings show no such time- -time changes, stability of the process is indicated. rom this, a most satisfactory appraisal of the product n be inferred, for a *statistically stable process produces statistically uniform product.* Thus the product ap- aisal which is indicated by control sampling is based reasoning from sample to process to product.

This concept is most important in paper manufac- re. The only convenient time to sample for control at the breaks between reels. The sampling in each se is a poor appraisal of either the preceding or follow- g reel; it is drawn from the very beginning of the e and the very end of the other. Quality throughout e reel is not directly appraised by such sampling. t the sampling is excellent as control sampling. If e control sampling indicates a stable process, the ality of the *continuous sheet* is statistically uniform, d thus the quality *throughout* the reels may be inferred th confidence.

CONCEPT 11: SATISFACTION OR ACTION

In routine quality control many inspections, tests, and measurements are made from time to time. Sometimes the data accumulated do little more than fill files. It is the responsibility of quality control to see to it that the greatest possible benefit is derived from these measurements. Each set of inspections, measurements, or tests should result in either satisfaction or action.

CONCEPT 12: DYNAMIC QUALITY CONTROL VERSUS STATIC QUALITY CONTROL

In static quality control, the objective is to control all important materials and processes within close limits, thus automatically controlling the quality of the finished product. This method has been used successfully in some industries. It has the advantage of simplicity in concept.

In dynamic quality control, significant variability in some important factor or factors is accepted as inevitable. The objective is to make compensating adjustments in other important factors. It has the disadvantage that much factual information must be assembled on the cause-and-effect interrelations of the various important factors and the finished product quality.

There is evidence that dynamic quality control is more appropriate than static quality control in many operations in the pulp and paper industry.

CONCEPT 13: FACTS VERSUS OPINIONS

The experience and process know-how which have been gathered in any industry are of tremendous value; they are, in fact, the indispensable ingredients of successful manufacturing. Yet mixed in with this experience and know-how are a large number of opinions which are not supported by facts.

The very existence of excessive dollar losses due to defective manufacture is evidence that more facts are needed to ferret out and eliminate the causes. Attempts to find new facts about cause-and-effect relationships are often hampered by strongly expressed opinions.

If a statement is known to be a fact, there are supporting data. If there are no supporting data, the statement is an opinion. The wise quality control engineer is guided by statements, but, in the absence of supporting data, leaves them open to further question.

CONCEPT 14: QUALITY OF DATA

Careful analysis of data can sometimes lead to valid conclusions which are not apparent in the raw data. The methods of statistics are useful in such an analysis. Many times a judicious rearrangement of the data will clearly point out the important interrelationships. Graphical methods are of great value in promoting mutual understanding in such matters.

No amount of analysis, however, whether by rearrangements, graphics, or statistics, can extract valid conclusions unless there is quality of data. This point is of great importance in analyzing data from experiments. The majority of experiments are improperly planned and executed. To apply careful methods of analysis to the data without searching inquiry into the design and execution of the experiments themselves is sheer statistical quackery.

CONCEPT 15: THE NATURAL LAW OF VARIABILITY

The natural law of variability is as universal and comprehensible as the law of gravity. Variability should be neither feared nor ignored. Fortunately it has another similarity to gravity and other laws of nature: it can be analyzed and treated scientifically.

General quality control (without statistics) sometimes fears variability and sometimes ignores it. Statistical quality control treats it scientifically by separating it into its component parts.

The foregoing concepts have been found valuable in promoting discussions and thus advancing mutual understanding within supervisory and technical staffs. This mutual understanding is of vital importance, for success in quality control is the result, not of the specialized skill of a few, but of the coordinated efforts of many.

Color Precursors in Spruce- and Western Hemlockwoods and Inner Barks

WARD PIGMAN, ERNEST ANDERSON, R. FISCHER, M. A. BUCHANAN, and B. L. BROWNING

Sprucewood inner bark and western hemlockwood contain materials which develop a red color upon treatment with mineral acids, preferably in the presence of alcohols. These materials appear to be leucoanthocyanins. The conditions affecting the tests have been studied systematically, and two semiquantitative methods for their determination are described. The leucoanthocyanins are present in black spruce inner bark and cambium but not in sprucewood. Related materials are found in all fractions of western hemlockwood, the inner bark, and the cambium in water-soluble and water-insoluble forms. Purified phlobatannins appear to be rich in leucoanthocyanins. The composition of the leucoanthocyanin from black spruce inner bark was studied. A methylated derivative and a crystalline acetate were prepared. It appears to have the formula $C_{15}H_9(OH)_3(C_6H_{11}O_6)$ and to be the hydroxylated derivative of a chalcone.

In the course of an investigation of the nature of the coloring matters and color precursors in western hemlockwood (*Tsuga heterophylla*) and of the composition of the inner bark and cambial layer of black spruce (*Picea mariana*, B.S.P.), it was observed that materials were present which gave a red color when heated with hydrochloric acid (*1*).

The present paper presents the results of an investigation of the nature of these materials and of methods for their determination and isolation. These particular color precursors appear to belong to the rather vaguely defined group of "leucoanthocyanins."

The presence in flowers and fruits of colorless or white materials which produce red colors upon treatment with strong acids has long been known. Robert Boyle (1844) made one of the first recorded observations. Erdmann (*2*) found that the sensitivity of the test could be increased by shaking the acidified extracts with amyl alcohol since the color passed into the alcohol layer. Willstätter and Everest (*3*) showed that a portion of the color of acidified solutions passed into the amyl alcohol in the cold and much more after the solution had been heated. These results were interpreted as indicating that the red-colored bodies existed as glycosides (later known as anthocyanins) and in sugar-free forms (anthocyanidins). The red colors turned blue when the solutions were made slightly alkaline and yellow when made more strongly alkaline.

In addition to the above materials, which give red colors with cold acids, many plant materials contain colorless or slightly colored materials which give deep red colors, with the characteristics of anthocyanidins, after treatment with hot or concentrated acids. Rosenheim (*4*) termed these leucoanthocyanins and extensive investigations of these materials have been made by the Robinsons. On the basis principally of color reactions and solubility behavior, the Robinsons (*5*, *6*) classified the resulting red-colored substances as anthocyanidins. Leucoanthocyanins* have, by these tests, been found in many flowers, fruits, vines, leaves, roots, seeds, grains, nuts, barks, woods, and peats. Cocoa was shown (*7*) to contain considerable amounts. Woods reported to contain leucoanthocyanins include ebony, eucalyptus, walnut, juniper, "soft pine," almond, pear, and yew. Müller (*8*) found that pine sapwood, but not heartwood, gave a red color with methanol-hydrochloric acid; beechwood and the wood of mountain ash gave particularly strong tests.

Isenberg (*11*) found incidentally that, when white fir sapwood was treated with anhydrous ethanol and *p*-toluenesulphonic acid, a violet color developed. Isenberg and Buchanan (*12*), Müller (*8*), and Wedekind (*9*) found that other alcohols, acetone, or dioxane in conjunction with hydrochloric, hydrobromic, or sulphuric acid, could be used to develop the red colors. The staining characteristics with methanol-hydrochloric acid of many woods was reported by Isenberg and Buchanan (*12*). According to Adler (*10*), the red coloration is due to a small amount of catechol tannin which reacts with coniferyl aldehyde groups in lignin. Quantitative methods for the determination of leucoanthocyanins have not been developed, although Fincke (*7*) made some studies of value in this connection.

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* The term leucoanthocyanins will be used in a general sense, without necessarily implying the presence of a sugar group in the molecule.

The structures of leucoanthocyanins have not been established. The solubility behavior and color reactions have indicated that the red substances formed on treatment with acid are anthocyanidins; in one instance cyanidin was isolated (*6*). Actual structural work has been limited to a study (*13*) of the sugar-free leucoanthocyanin (peltogynol) from the heartwood of *Peltogyne porphyrocardia*, *P. pubescens*, and *Copaifera pubiflora*. This leucoanthocyanin was a colorless, dextrorotatory, crystalline material, which could be converted into a triacetate and a tri- and a tetramethyl ether. An open hemiketal structure was proposed. Previously, the Robinsons (*5*) had proposed that the leucoanthocyanins might be anthocyanidins hydrated at the 3,4-position or be open-chain hydrated forms.

Other suggestions for the structures of leucoanthocyanins have been made by Stephens (*14*) and by Rosenheim (*4*). Quite possibly there are different types of leycoanthocyanins, some of which may yield known anthocyanidins and others of which may yield unusual types of anthocyanidins or closely related substances. It is interesting to note that Willstätter (*15*) in his early work found that cyanidin could be converted into a colorless crystalline modification which apparently fits the usual criteria for leucoanthocyanins.

PREPARATION OF THE COLOR PRECURSORS

Western Hemlockwood

The sapwood and heartwood from a portion of a western hemlock tree (70 yr. old) were converted into sawdust, air dried on trays protected from direct light, and extracted with benzene in a large Soxhlet apparatus for hr. The air-dried extracted sawdust contained about 5% moisture. In some cases noted specially, sapwood and heartwood were kept separate; otherwise, the mixture in natural proportions was used. The inner bark was treated in the same manner as that described for black spruce in the next section.

In preliminary work, the suitability of various organic solvents and mixtures with water for the extraction of the visual coloring bodies and the color precursors was tested. Aqueous alcohols and acetone gave the best results and 50% ethanol was selected as the solvent. As this work also showed that the color precursors were at least partially destroyed by Soxhlet extraction, percolation at room temperature was employed.

The following procedure was used for the extraction. Sawdust after benzene extraction and air drying, in lots of about 1250 grams, was placed in a large conical percolator and tamped down. Six liters of 50% (by volume) ethanol were added. After 18 hr. about 4 liters were drained off and replaced with fresh solvent. The extraction was carried out three times and the extracts were combined. This procedure removed about two thirds of the material that could be obtained by exhaustive extraction. A total of 5.13 kg. of sawdust was extracted in this manner.

The combined extracts (about 60 liters) were concentrated *in vacuo* to about 4 liters. During the process, a solid separated which was removed by centrifugation. The cloudy solution was allowed to freeze and thaw, and the solid material was separated. The solution was concentrated to about 900 ml. and again treated in the same fashion. The combined air-dried fractions, reddish brown in color, weighed 59.7 grams, a yield of 1.3%. This material is called the impure western hemlockwood leucoanthocyanin. It contained the bulk of the color precursors of the extract. The water-soluble material was not extensively studied, but it contained some color precursor which is not extractable by ethyl acetate and which is glycosidic in nature or is accompanied by glycosides (material yielding reducing sugars on hydrolysis). The major portion of the visual coloring bodies of the extracts remained in the water and was insoluble in ethanol.

Spruce Inner-Bark Leucoanthocyanin

Two black spruce trees, about 60 yr. of age, were cut into logs, from which, within several days, the bark was removed. The inner bark was peeled from the outer bark in strips and allowed to dry in the air. The air-dried material, which represented 3.9% of the weight of the logs, was ground in a Wiley mill, extracted exhaustively with benzene, and again air dried.

A 524-gram portion of the benzene-extracted inner bark was placed in a Soxhlet apparatus and extracted with 95% ethanol for 18 hr.† The solution was concentrated to dryness *in vacuo* and the residue (131 grams) was taken up in 2 liters of water. To the solution were added 660 grams of sodium chloride. The precipitate was removed by filteration; the filtrate was concentrated *in vacuo* to about 500 ml. and extracted three times with 2-liter portions of ethyl acetate. The combined extracts were dried with sodium sulphate and sodium bicarbonate, filtered, and concentrated to about 500 ml., at which time solid material began to separate. The solution was again dried with sodium sulphate, filtered, and added slowly through a capillary to 6 volumes of petroleum ether (b.p. 30 to 60°) which was stirred rapidly with a mechanical stirrer. The white powder, dried in a vacuum desiccator, weighed 13 grams, a yield of 2.5%.

Some purification was accomplished by solution of 4 grams of the material in 20 ml. of water, and extraction several times with ether (which was discarded), and then with three 100-ml. portions of ethyl acetate. The combined ethyl acetate extracts were dried, concentrated to 100 ml., and precipitated into petroleum ether as described above. The yield was 2.4 to 3.0 grams of a white powder.

This material was a glucoside, and its properties and composition will be discussed in a later section. It is given the name of black spruce inner-bark leucoanthocyanin.

COLOR TESTS AND QUANTITATIVE METHODS

Modified Erdmann Test. Several milligrams of leucoanthocyanin material and 1 ml. of water were placed in a test tube and about 6 ml. of approximately 6 *N* hydrochloric acid were added. The solution was boiled several minutes over a free flame, cooled, and 2 ml. of amyl alcohol were added. The two layers were shaken together and allowed to separate. The amyl alcohol layer exhibited a bright red color.

When it was desired to show the color of neutral or

† In view of the later finding that 50% ethanol at room temperature is probably the preferred solvent, a modification of this procedure seems desirable.

alkaline solutions, the procedure was modified. The hydrolysis was carried out as above with a solution of the following composition: One milliliter of water containing the leucoanthocyanin material, 2 ml. of 6 *N* hydrochloric acid, and 3 ml. of ethanol or propanol. After the solution had been heated and cooled, the resulting red color changed rapidly to blue upon the addition of an excess of calcium carbonate. When concentrated ammonium hydroxide was added dropwise, the color passed through a transient blue, followed by a green and, finally, a fairly permanent yellow.

Qualitative Methanol-Hydrochloric Acid Test. Isenberg and Buchanan (*12*) recommended that the reagent be made by the addition of 25 ml. of concentrated hydrochloric acid to 1 liter of methanol. Air-dried sawdust or shavings were placed in a test tube and covered with this reagent. A positive test was indicated by the development of a purplish-red color on the surface and in the solution within 15 min. to 24 hr. at room temperature.

This test is markedly affected by the presence of water and perferably should be carried out under anhydrous conditions. However, it has qualitative value as described. Colors of this shade which develop after 24 hr. are probably the result of the hydrolysis of materials like the spruce inner-bark leucoanthocyanin, which do not show the color after short time periods.

Quantitative Propanol-Hydrolysis Method for Leucoanthocyanins. Five milliliters of a solution of 1 to 2 mg. of color precursor in propanol were placed in a 10-ml. volumetric flask, 2 ml. of 3.0 *N* hydrochloric acid were added, and the solution was made to volume with propanol. The contents of the flask were poured into a test tube (20 by 150 mm.) equipped with a glass stopper, and the stopper seated tightly. The test tube was placed in boiling water and heated 40 min. It was then removed, cooled with tap water, and the contents were poured into a 1-cm. spectrophotometric cell. The absorbance‡ of duplicate solutions at 540, 545, and 550 mmu was measured and averaged.

$$\text{The absorptivity at 545 mmu} = \frac{\text{observed absorbance in 1-cm. cell}}{\text{mg. solid in 1 ml.}}$$

Some of the materials did not dissolve readily in anhydrous propanol, but dissolved when water was added to the original stock solution. The composition of the final solution was kept unchanged by the use of 1 ml. of 6.0 *N* hydrochloric acid. Preferably for highest accuracy, the concentration of color precursor should be adjusted so that the final transmittance is in the range of 20 to 30%.

Quantitative Methanol-Hydrochloric Acid Method. Five milliliters of 1 to 2 mg. of color precursor in dry methanol were pipetted into a 10-ml. volumetric flask, 4 ml. of 0.483 *N* hydrochloric acid in dry methanol were added, and the solution was made to volume with dry methanol. After 17 to 24 hr. at room temperature (20 to 25°), the absorbance of the solution was measured as described above for the propanol-hydrolysis method.

FACTORS INFLUENCING COLOR DEVELOPMENT

Propanol-Hydrolysis Method. The black spruce inner-bark leucoanthocyanin dissolved readily in dilute aqueous hydrochloric acid. When the solution was boiled for several minutes, it turned red and an insoluble precipitate appeared. The precipitate dissolved upon the addition of alcohols to give a brownish-red solution exhibiting general spectral absorption in the visible region, with the absorption increasing toward the blue region and with no marked maxima. When alcohols were present during the heating period, the final solution was a bright carmine red with a strong absorption maximum at about 545 mmu. The western hemlock-wood leucoanthocyanin, initially water insoluble, behaved similarly and gave the same type of spectral absorption curve. The spectral absorptions of the two materials are shown in Fig. 1. Generally it was found that maximum color development was reached in less than 40 min. at 100°.

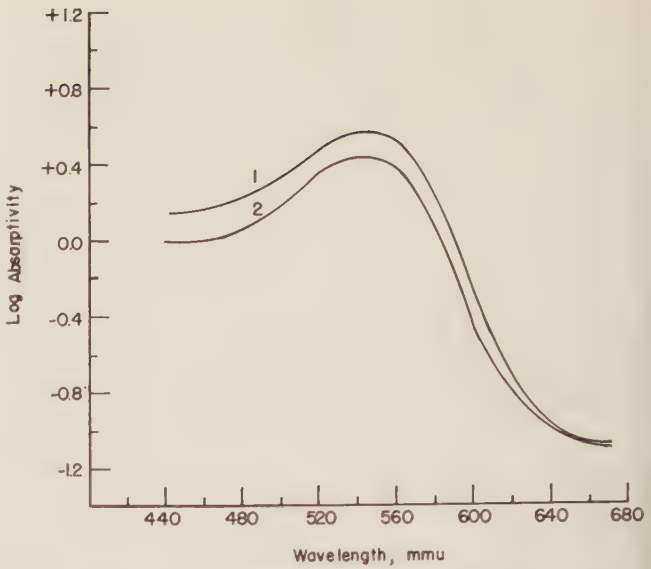


Fig. 1. Spectral curves for propanol-hydrolysis method

(1) Water-insoluble fraction of 50% ethanol extract (western hemlock). (2) Leucoanthocyanin (spruce).

The effect of the acidity and water content is shown in Table I for the spruce leucoanthocyanin. The maximum color development is shown under essentially anhydrous conditions with low concentrations of hydrogen chloride. In similar experiments with the hemlock leucoanthocyanin, water exhibited very little effect in the concentration range of 0 to 20%. Because of the difficulties arising from the use of anhydrous solvents, and because many of the wood materials are not soluble under anhydrous conditions, it was decided for routine operations to use 80% propanol, 0.6 *N* in hydrochloric acid, and a heating time of 40 min. at 100°. These conditions are called the "standard conditions" and are described in detail in the preceding section. The spectral absorption curves under these conditions are shown in Fig. 1.

After formation, the red colored material may be diluted with 80% propanol and the absorbance at 545 mmu is inversely proportional to the dilution (Beer's Law). However, as shown in Table II, the absorptivity in the propanol-hydrolysis method is not independent of the initial concentration of leucoanthocyanin.

A 50-fold variation in the original concentration produced a change of absorptivity from 2.3 to 4.3.

‡ The nomenclature used is that recommended in *Anal. Chem.* 24: 1349 (1952).

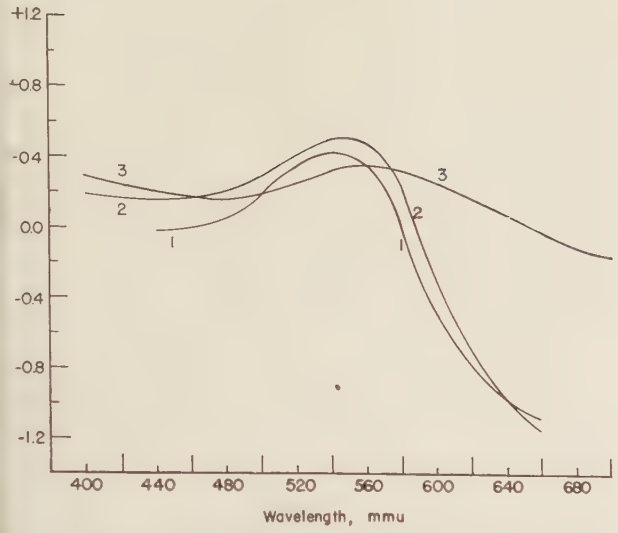


Fig. 2. Spectral curves for spruce leucoanthocyanin under conditions of propanol-hydrolysis test

(1) "Standard" propanol hydrolysis (80% propanol). (2) Anhydrous propanol-HCl (acid solution). (3) Anhydrous propanol-HCl (neutral solution).

Subsequently, to minimize the effect of concentration, quantities of materials were taken so that the final transmittance of the solution was in the range 0.2 to 0.4.

Many of the materials from woods exhibit a color before treatment with the acid. However, the measurement of the absorbance at 545 mmu for a number of wood fractions containing leucoanthocyanins showed that only rarely is the original absorbance as great as 10% of that finally developed. For materials low in or free from leucoanthocyanins, such as spruce native lignin, atypical colors, usually of considerable less intensity, were produced. The red solutions produced from the spruce leucoanthocyanin exhibited no change in absorbance as a result of standing for 48 hr. in the dark. A very slow decrease in absorbance at 545 mmu occurred upon exposure of the solution to indirect sunlight. The absorbance at 440 mmu gradually increased in diffuse light and in the dark. In effect, the aging caused a "browning" of the solution. When, just prior to the heating period, the solutions were flushed with oxygen or nitrogen by allowing the gases to flow through the solution for several minutes and then quickly closing the tubes, the final color was the same as that developed under the usual conditions. Unless only small amounts were required, oxygen did not seem to affect the development of the color.

Table I. Effect of Changes of Concentration of Acid, Water, and Propanol

1 Mg. Spruce Leucoanthocyanin/10 Ml. Heated 40 Min. Under Standard Conditions

Propanol, % by vol.	*H_2O, % by vol.*	*HCl, N*	*Absorptivity at 545 mmu*
80	20	1.8	2.4
80	20	1.2	2.6
80	20	0.6	2.7
80	20	0.3	2.1
80	20	0.1	1.1
90	10	0.6	2.3
90	10	0.3	2.8
100	0	0.3	2.9
100	0	0.3	2.9
100	0	0.12	3.2
100	0	0.03	4.3
100	0	0.015	4.2

Table II. Effect of Concentration of Spruce Leucoanthocyanin on the Absorptivity Under Standard Conditions

Concn. of leucoanthocyanin, mg./10 ml.	*Absorptivity at 545 mmu*
5	2.3
3	2.5
2	2.8
1	3.2
0.5	3.8
0.2	4.3
0.1	4.2

Solutions of the red-colored material were formed from the spruce or the hemlock leucoanthocyanin in anhydrous propanol containing hydrogen chloride. When these were treated for several minutes with an excess of calcium carbonate and then clarified by centrifugation, they exhibited a grayish-blue color, the spectral curve for which is given in Fig. 2. In this curve, the maximum is shifted only to about 560 mmu, but the general absorption at the red end of the spectrum increased greatly. When the solution was made definitely alkaline, as by the addition of several drops of concentrated ammonium hydroxide, a bright yellow color was produced. Acidification of the solution at the stage of the blue color caused a return of the original red color, but acidification at the yellow stage produced an orange-red solution. The orange-red solution upon being made neutral or slightly alkaline did not give a blue color but gradually faded into the yellow color. Thus, the color changes were reversible at the blue stage, but not at the yellow stage. These color changes were generally similar to those described for known anthocyanins. Apparently, less alkaline conditions are required for the development of the blue color than is the case for known anthocyanidins (*16*).

Methanol-Hydrogen Chloride Method. The hemlock leucoanthocyanin material, when dissolved in anhydrous methanol containing hydrogen chloride, rapidly developed a deep purplish-red color after a few minutes at room temperature. This color is probably the same as that observed by Isenberg and Buchanan when many woods were treated with aqueous methanol-hydrogen chloride. A similar color could be produced by plac-

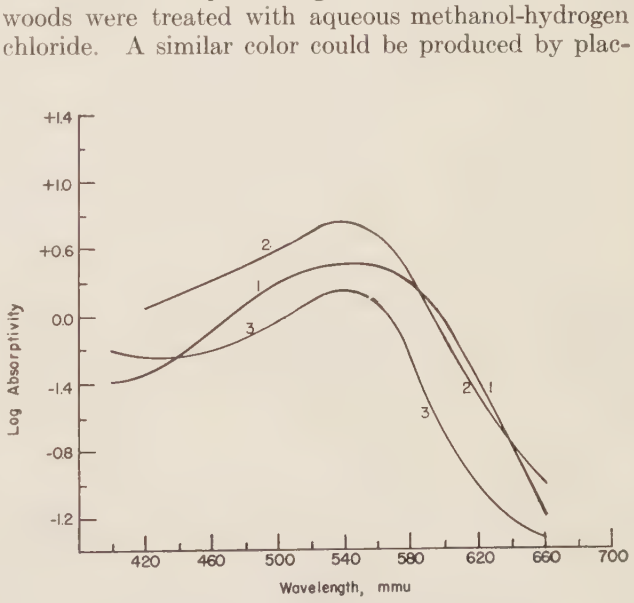


Fig. 3. Water-insoluble fraction of 50% ethanol extract anhydrous methanol-HCl test

(1) t = 15 min. (2) t = 47 hr. (3) Leucoanthocyanin (152 hr.).

ing a shaving of western hemlockwood (particularly of the sapwood) in the reagent, but no color was produced from shavings of black spruce under similar conditions.

Previously Isenberg and Buchanan (*12*), as well as Müller (*8*), made some studies of the composition of the reagent in relation to the color developed. In attempts to place the test on a quantitative or semi-quantitative basis, a study of the variables influencing the color development was made in the present investigation. One of the first observations was that the color of the solutions changed upon standing at room temperature from a purple red to a bright carmine red, similar to that produced in the propanol-hydrolysis method. The spectral curves for the hemlock leucoanthocyanin in anhydrous methanol-hydrogen chloride after 15 min. and after 48 hr. at room temperature are shown in Fig. 3.

The spruce leucoanthocyanin when dissolved in methanol-hydrogen chloride developed a color only very slowly at room temperature and the color that developed was the typical carmine red of the propanol-hydrolysis reaction. Its spectral curve after 152 hr. is given in Fig. 3. The shape is very similar to that of the hemlock leucoanthocyanin curve at 47 hr.

The rate of the development of the color was studied for the hemlock leucoanthocyanin under anhydrous conditions as a function of the hydrogen chloride concentration over the range 0.048 to 0.241 *N* hydrogen chloride. The rate curves shown in Fig. 4 were composed of a rapid initial production of color, a second almost stationary stage and, finally, a period of second production of color. A concentration of hydrogen chloride greater than 0.2 *N* seemed to be of little value in obtaining maximum final color production.

A few studies were made of the effect of water on the rate and extent of color development. It was found that as little as 0.3% water in the reagent caused a noticeable slowing down of the first reaction. With 10% water and 0.2 *N* hydrogen chloride, the absorptivity at 545 mmu after 90 hr. was only 0.48, whereas it was 3.5 under anhydrous conditions. In the presence of water, the solutions tended to develop the

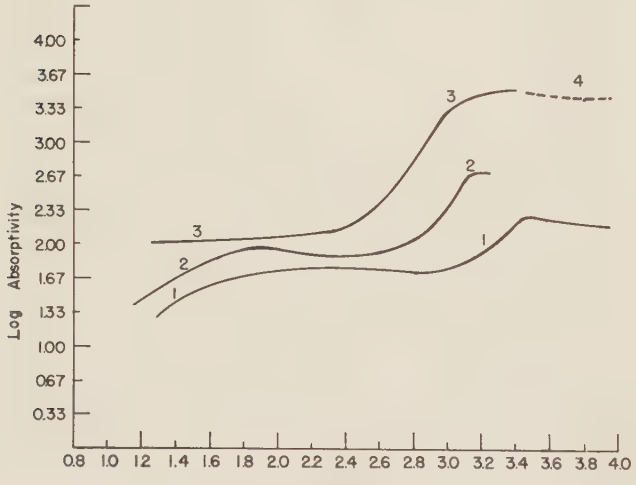


Fig. 4. Rate of development of methanol-HCl color and effect of HCl concentration

(1) 0.0483 *N* in HCl. (2) 0.0965 *N* in HCl. (3) 0.1940 *N* in HCl. (4) 0.2413 *N* in HCl.

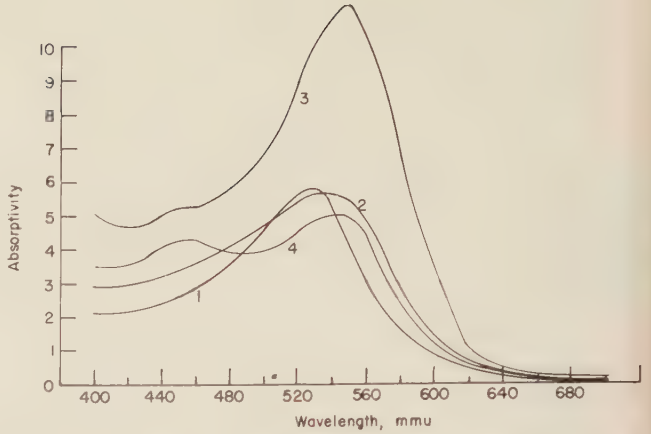


Fig. 5. Propanol-hydrolysis tests of tannin extracts (spectral curves)

(1) Quebracho extract. (2) Wattle extract. (3) Mangrove extract. (4) Western hemlock bark tannin.

carmine-red rather than the purple-red color and possibly the initial stage illustrated in Fig. 4 may have been considerably suppressed. No aging effect could be noticed for the reagent when stored in a refrigerator for several months.

The two stages in the color development could also be distinguished by the colors which developed upon the careful dropwise addition of concentrated ammonium hydroxide. At the first stage, when the acidic solution was purple red (one-half to several hours), only a yellow color was produced upon the addition of the alkali whereas, after the second stage (one or more days), when the acidic solutions exhibited a carmine-red color, the color became successively blue, green, and yellow as the alkali concentration increased. The latter behavior was the same as that observed for the red colored material produced in the propanol-hydrolysis reaction.

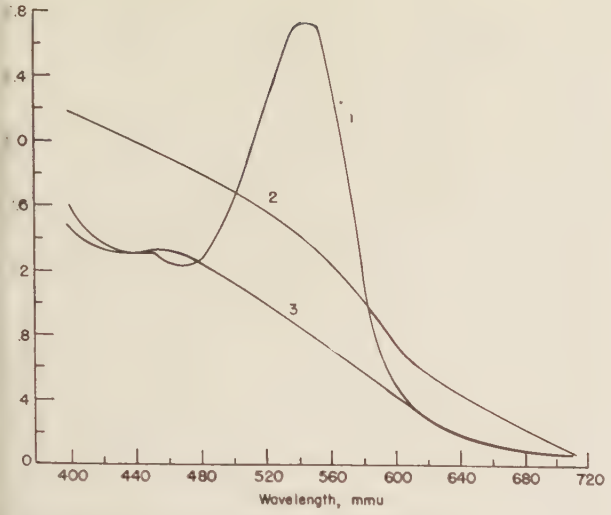
Because of the speed with which the initial color development takes place under mild conditions, it seems likely that only a tautomeric change of some type occurs. When the hemlock leucoanthocyanin was dissolved in the methanol-hydrogen chloride reagent and recovered by evaporation of the solvent, the analytical results for carbon, hydrogen, and methoxyl showed no significant change from those for the original material and no chlorine was present.§ Unless the color precursor is present in only very small amounts, these results again indicate a tautomeric change.

The two stages of the reaction in the anhydrous methanol-hydrogen chloride reagent seem to be consecutive and not independent. The color of the slightly alkaline solution at the first stage was yellow and at the second stage was blue. Since these are primary colors, the blue of the second stage could not contain a significant amount of the yellow component remaining from the first stage.

DISTRIBUTION OF COLOR PRECURSORS IN WESTERN HEMLOCKWOOD AND IN TANNING MATERIALS

The distribution of color precursors in various fractions of the wood and bark of western hemlock and in

§ On a moisture- and ash-free basis, these analyses were as follows: Before treatment, C, 63.1; H, 5.3; OCH_3, 10.6. After treatment, C, 63.7; H, 5.2; OCH_3, 11.4. The product was partially purified with an absorptivity of 6.2.



6. Spectral curves for the hydrolyzed spruce leucoanthocyanin

(1) Propanol-hydrolysis curve. (2) Water-insoluble material hydrolysis with aqueous acids (redissolved in ethanol).) Same as 2 but in 80% propanol, 0.6 *N* in HCl, 1 yr. later.

number of tanning materials was studied by use of e propanol-hydrolysis method.

For the studies with western hemlock, freshly pre- ared air-dried sawdust from the sapwood, heartwood, inner bark (which included most of the cambial yer) of mature wood was extracted with benzene and ried in the air. The extracted materials were ex- acted further by a percolation procedure with 50% hanol. When the ethanol solution was concentrated *vacuo* and most of the alcohol removed, a precipitate water-insoluble material was obtained; the remaining lution contained the water-soluble components of e extract. An analysis of each fraction for leuco- nthocyanins was made, using the propanol-hydrolysis ethod. The results, recorded in Table III, show that e inner bark (including the cambial layer) is by far e richest source of leucoanthocyanins, particularly of e water-soluble variety. The heartwood contained ly a small amount, which was of the water-insoluble pe; the latter was present in the sapwood in relatively gh amounts.

Qualitative studies with black sprucewood showed at this wood contained little or none of this type of lor precursor, although the isolation of the spruce ucoanthocyanin from the inner bark and the cambial

able III. Distribution of Leucoanthocyanins in Western Hemlockwood and Inner Bark

	Freshly cut wood fractions		
	Inner bark and cambium	*Sapwood*	*Heartwood*
eld[a]			
Total 50% ethanol extract	19.1	1.40	1.53
Water-insoluble fraction	1.13	0.79	1.15
Water-soluble fractions	18.0	0.61	0.38
sorptivity at 545 mmu (propanol hydrolysis)			
Water-insoluble fraction	8.2	6.4	0.65
Water-soluble fractions	8.0	2.2	0.0
sorptivity calculated on the basis of the original wood substance			
Water-insoluble fraction	0.093	0.051	0.0
Water-soluble fractions	1.44	0.013	0.0

[a] Percentage on basis of oven-dried benzene-extracted wood. These lds represent only partial extractions under similar conditions.

Table IV. Analyses of Commercial Tannin Extracts and Purified Tannins by the Propanol-Hydrolysis Method

Tannin	*Absorptivity at 545 mmu*	
	Original extract[a]	*Purified tannin*[b]
Quebracho	5.0	5.5
Wattle	5.7	...
Mangrove	10.9	8.8
Western hemlock bark	5.0	...
Chestnut	Negative	Negative
Myrobalans	0.2[c]	0.3[c]
Tannic acid	0.8[c]	...

[a] Commercial extracts, except that the western hemlock tannin was made by aqueous extraction of bark, precipitation with sodium chloride, and extraction from the precipitate with acetone.
[b] Purified; 90–100% tannin by A.L.C.A. method.
[c] Atypical colors, probably mainly the original color. For the mangrove extract, the original absorptivity at 545 mmu was 0.5 and for the western hemlock tannin was 0.55.

material showed that it was present in this portion of the tree.

The method was also applied to the determination of leucoanthocyanins in representative commercial tanning extracts and in several high purity tannins derived therefrom (*18*). The behavior of these materials at the dropping mercury electrode has been reported previously (*17*). As indicated in Table IV, the phlobaphene group of tannins (quebracho, wattle, mangrove, western hemlock) were rich in leucoanthocyanin materials. The so-called hydrolyzable tannins, represented by chestnut and myrobalans tannins and commercial tannic acid, gave essentially negative tests. The spectral curves for several of these materials are given in Fig. 5. The curves are generally similar to those for spruce leucoanthocyanin but the absorptivity is greater. The maximum for quebracho and wattle was shifted to shorter wavelengths (525 mmu for quebracho and 535 mmu for wattle).

CHARACTERIZATION OF THE SPRUCE LEUCOANTHOCYANIN

The leucoanthocyanin from black spruce inner bark

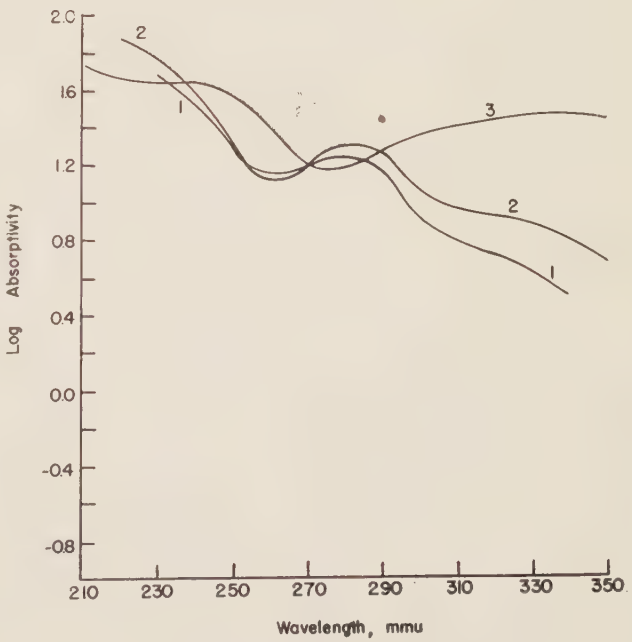


Fig. 7. Ultraviolet absorption curves

(1) Spruce native lignin in dioxane. (2) Spruce leucoanthocyanin hydrolysis product (aq. HCl). (3) Spruce leucoanthocyanin in water.

was a white or slightly yellowish amorphous powder, quite soluble in water, alcohols, acetone, and ethyl acetate. Although amorphous, it gave a crystalline acetate in good yield. The melting point of the leucoanthocyanin was not sharp and fell in the range 132 to 145°C. for various preparations. Crude products had $[\alpha]_D^{20}$ of −30 to −35° in water; purified products had rotations of −54.6 to −57.9° (water, 2%); products aged for 1 yr. showed maximum rotations of only about −47°. After exposure to indirect sunlight for several months, considerable surface browning was noticeable.

The leucoanthocyanin reduced hot Fehling solution only slightly but, after acid hydrolysis, it reduced strongly. After treatment with hot acids in the presence of alcohols, a red color was produced. The absorptivity by the propanol-hydrolysis method varied over the range 2.4 to 2.7; the spectral curve under these conditions is given in Fig. 6. When the hydrolysis was carried out with hot aqueous acids, a brown precipitate formed which, when dissolved in ethanol, gave the spectral curve shown in Fig. 6. Hot 5% aqueous potassium hydroxide caused the development of a characteristic deep wine-red color. Bromine water reacted to form an insoluble brown precipitate. No furfural or methylfurfural was produced by the action of boiling 12% hydrochloric acid.

The ultraviolet absorption of spruce leucoanthocyanin is shown in Fig. 7, which also gives curves for spruce native lignin and the material obtained by hydrolysis of the leucoanthocyanin with aqueous mineral acids. The leucoanthocyanin, unless aged, gave colorless aqueous solutions. At pH 10, the solution was yellowish brown and the color deepened rapidly upon standing.

Solutions of the leucoanthocyanin (*c* 0.1 to 0.3%) in carbon dioxide-free distilled water were titrated potentiometrically with 0.05 *N* sodium hydroxide. A point of inflection at pH 10.1 corresponded to an equivalent weight of 247.

Molecular weight measurements gave 480 to 520 (Rast camphor method) and 570 (elevation of the boiling point of water).

Hydrolysis with Aqueous Acids

Hydrolysis of 0.2% solutions of a crude leucoanthocyanin preparation with 2% hydrochloric acid in a boiling water bath showed that the reducing power increased rapidly for the first 45 min. and thereafter only very slowly.

A sample of purified leucoanthocyanin with $[\alpha]_D$ −47° and absorptivity at 545 mmu of 2.2 was refluxed with 20 ml. of 2% hydrochloric acid for 50 min. The cooled solution was neutralized with solid sodium carbonate, treated with an excess of a saturated solution of neutral lead acetate, and the excess of lead ions was removed by treatment with sodium oxalate. The reducing sugar determination, made on the final clarified solution by use of the Munson-Walker method, corresponded to 40.2% of glucose. Another hydrolyzate gave 40.7% of glucose.

Three grams of purified leucoanthocyanin were refluxed with 100 ml. of 2% hydrochloric acid for 50 min. The precipitated material, when separated and dried, weighed 1.062 grams. Extraction of the aqueous solution four times with amyl alcohol and precipitation of the extract into petroleum ether gave an additional 1.093 grams of material which was combined with the first precipitate; total yield, 2.155 grams or 71.5% of the original weight. This material was completely soluble in 95% ethanol, methanol, and amyl alcohol, and had an absorptivity (atypical color) of 1.2 (propanol hydrolysis). Elementary analyses gave: C, 68.7%; H, 5.95%; OCH_3, 8.9%. The spectral absorption curve for the material is given in Figs. 6 and 7.

The aqueous layer from the hydrolysis of the 3-gram sample of leucoanthocyanin was heated on a boiling water bath with 3 grams of phenylhydrazine hydrochloride and 4 grams of sodium acetate. Bright yellow needles appearing much like glucosazone separated. The yield of dried crystals was 0.3 gram; they melted at 204°C. When recrystallized from 70% alcohol, the product had a melting point of 208–210°C., and the mixed melting point with authentic glucosazone was the same.

Acetylation

A 1-gram portion of leucoanthocyanin ($[\alpha]_D$ −47.7° in water) was dissolved in 7 ml. of pyridine and the solution was cooled to 0°. Five milliliters of acetic anhydride at 0°C. were added and the solution was kept at 0 to 4° for 48 hr. It was then poured with stirring into 25 ml. of ice and water. A sticky gum was produced which powdered when rubbed with water. The separated material weighed 1.45 grams, had $[\alpha]_D$ −7.7° in chloroform, and melted at 136 to 144°C.

The crude material (1.45 grams) was dissolved in 50 ml. of boiling ethanol (95%). When the solution cooled, needle-like crystals separated. The dried crystals weighed 0.9 gram, melted at 153 to 154°, and had a rotation of $[\alpha]_D^{20}$ −15.2° in chloroform. A second similar recrystallization gave a product with unchanged properties.

The analytical data for the final product were: C, 58.8%; H, 5.4%; CH_3O 3.86%; CH_3CO, 40.4 and 39.2%. The higher acetyl value was given by the E. P. Clark method (alkaline saponification followed by acid distillation), and the low value by the Freudenberg and Harder method (hydrolysis with *p*-toluenesulphonic acid).

Methylation

The methoxyl content of the spruce leucoanthocyanin showed some variation with the particular preparation. Three values were: 5.6, 6.0, and 6.2% OCH_3. The material was further methylated as follows.

Two grams of purified spruce leucoanthocyanin were dissolved in 150 ml. of methanol. The yellow-orange solution was cooled in ice water. Diazomethane prepared from 10 grams of nitrosomethylurea was distilled into the cooled solution. After standing overnight, the solution was warmed slightly under reduced pressure in order to remove the ether which had distilled with the diazomethane. Two additional methylations were made in the same manner. The diazomethane was rapidly exhausted in the first methylation but remained for some time during the second and third methylations.

The methanol solution of the methylated product was dried over a mixture consisting of 10 grams of anhydrous sodium sulphate and 2 grams of sodium carbonate. (No color was taken up by the drying agents.) The dried solution was filtered and concentrated to 28 ml. A small amount of this solution, when poured into a large excess of low-boiling petroleum ether separated as a liquid rather than as a solid product. The main part of the solution was added dropwise to 600 ml. of absolute ethyl ether. This resulted in the precipitation of a flocculent product which was washed with absolute ether and then with petroleum ether. This product, which is referred to as the first fraction, was obtained in a yield of only 0.4 gram; the methoxyl content was 14.6%.

In order to isolate the remainder of the methylated product, the ether mother liquor was combined with the wash liquors. Methanol was added and the solution was concentrated under reduced pressure to 20 ml. The product was isolated by adding the dried solution dropwise to 600 ml. of low-boiling petroleum ether. The oillike material which separated, was stirred with a mixture of 20 ml. of petroleum ether and 30 ml. of absolute ether. This resulted in the formation of a solid product which was washed once with 30 ml. of absolute ether and then with petroleum ether. After drying, this fraction weighed 1.9 grams; it had a methoxyl content of 20.2%, and an absorptivity of 0.8 by the propanol-hydrolysis method.

In order to interpret the analytical data in terms of possible structures, it is necessary to postulate the basic structural type. On the basis of Robinson's observations (*6*) that acids convert leucoanthocyanins to anthocyanidins, a probable assumption is that a C_{15} nucleus is present. As shown by the data given above, glucose, hydroxyl groups, and methoxyl groups are present in the spruce leucoanthocyanin. If one C_{15} unit, one glucose group, and one methoxyl group are present, the empirical formula can be calculated on a C_{22} basis. The heptaacetate consequently would be a C_{36} compound.

On a C_{22} basis, the elementary analyses given in Table V for the spruce leucoanthocyanin indicate a probable empirical formula of $C_{22}H_{27}O_{10}$, or $C_{15}H_{13}O_3(OCH_3)(C_6H_{11}O_6)$ with two acidic hydroxyls.

The acetyl analyses on the acetylated leucoanthocyanin agree best with those for the heptaacetate, a C_{36} compound. On a C_{36} basis, the empirical formula is $C_{36}H_{39.4}O_{16.5}$, including acetyl $(CH_3CO)_{6.9}$ and $(OCH_3)_{0.91}$. Since the molecule appears to contain seven acetyl groups, one glucose group, and one methoxyl group, the calculated formula is: $C_{15}H_{8.4}O_{2.5}(COCH_3)_3(OCH_3)[C_6H_7O_6(COCH_3)_4]$. It seems fairly certain from this formula that all the oxygen atoms are constituents of acetoxy or methoxyl groups and, hence, that the leucoanthocyanin has the formula $C_{15}H_{8-9}(OH)_3(OCH_3)$.

Direct analysis of the leucoanthocyanin, as shown above, gave $C_{15}H_{10}(OH)_3(OCH_3)(C_6H_{11}O_6)$, a formula closely similar to that derived from the acetate and differing only in the number of hydrogen atoms. At this time, on the assumption of a C_{15} nucleus, the most probable formula appears to be $C_{15}H_9(OH)_3(OCH_3)(C_6H_{11}O_6)$ for the leucoanthocyanin. Since the acetate was a crystalline substance, its analysis was given some preference in the final choice of H_9. Consequently, that for the sugar-free material is most likely $C_{15}H_9(OH)_4(OCH_3)$. The analytical data for the hydrolysis product only approximate the values predicted by this formula, but it appears likely that the hydrolysis product was impure.

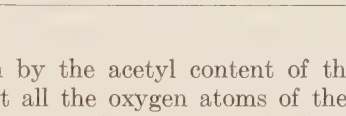
A summary of the observed analyses and the values calculated on the basis of these formulas is given for the leucoanthocyanin and its acetate in Table V. The observed values for the acetate agree fairly closely with those calculated. Those for the leucoanthocyanin show some deviation, particularly in methoxyl values, presumably because of contamination with a material of smaller methoxyl content.

Table V. Elementary Composition of the Spruce Leucoanthocyanin and Its Acetate Based on $C_{15}H_9(OH)_3(OCH_3)(C_6H_{11}O_6)$

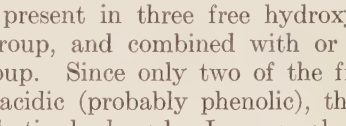
Constituent	Leucoanthocyanin Found			Leucoanthocyanin Theory	Heptaacetate Found	Heptaacetate Theory
C, %	58.3	59.3	58.4	58.6	58.8	58.1
H, %	6.2	6.0	6.0	5.8	5.4	5.41
OCH_3, %	6.2	6.0	5.6	6.9	3.9	4.16
CH_3CO, %	.....			...	40.4	40.4
Molecular weight	.....			450.4	...	744.7

As shown by the acetyl content of the acetate, it appears that all the oxygen atoms of the leucoanthocyanin are present in three free hydroxyl groups, a methoxyl group, and combined with or a part of a glucosyl group. Since only two of the free hydroxyl groups are acidic (probably phenolic), the third may be an aliphatic hydroxyl. In general confirmation of this structure, the fully diazomethane-methylated leucoanthocyanin had a methoxyl content of 20.2%, which may be compared with that of 19.4% calculated for the compound in which the two acidic hydroxyls had been methylated.

If the original assumption of the presence of a C_{15} nucleus is correct, the formulas which fit the currently available evidence are of the type:



(I)

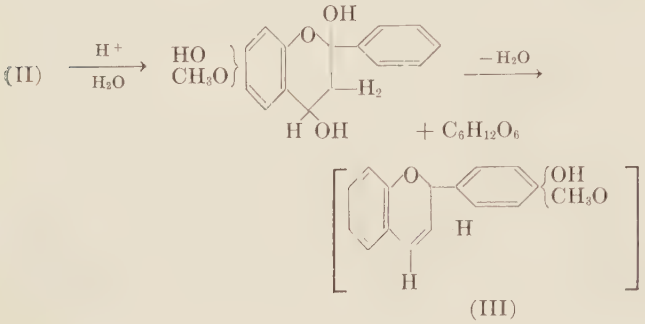


(II)

Other than the evidence that one hydroxyl is not acidic and, hence, is probably alcoholic, there is no direct evidence for the positions of the substituent groups. The following consideration of the possible mode of formation of anthocyanidins from such structures necessitates the placing of one phenolic hydroxyl group in the 2-position and of the glucosyl group in the central aliphatic chain. These structures are very similar to one of the possibilities suggested by the Robinsons in their early work.

The conversion to anthocyanidins could occur as a result of ring closure, hydrolysis of the sugar group, and dehydration, such as shown in accompanying formulas.

The reactions involved have been demonstrated for similar types of compounds (*19-23*).



(III)

Further work will be required to establish the complete structure of the spruce leucoanthocyanin, but the formulas proposed should be of value in the final establishment of the structure of at least one type of leucoanthocyanin. Obviously, degradative studies carried out on the methylated and/or hydrogenated leucoanthocyanin would be of considerable help in the establishment of the positions of the substituent groups and in confirming the general structural pattern. Because of the previously demonstrated relationship of these leucoanthocyanins to the phlobatannins and probably to other wood constituents, it is possible that the establishment of the structures of these compounds may be the clue that will reveal those of more complex structures. It is of interest in this connection that, as shown in Fig. 7, the spectral absorption curve in the ultraviolet for the red material obtained by aqueous acid hydrolysis of the leucoanthocyanin exhibited many close resemblances to that of Braun's native lignin.

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Received Nov. 14, 1952.

This work was begun originally at the suggestion of Harry F. Lewis and was carried out at The Institute of Paper Chemistry. Most of the analytical work was done by Marilyn Podest and Robert Buxton. A portion of this work was supported by the Crown Zellerbach Corp., and the cooperation of Walter Holzer and Wendell Moyer is gratefully acknowledged.

Methods of Increasing the Efficiency of Wet-Strength Resins

J. VERNON KINDALL and JOHN B. DAVIDSON

A study has been made to determine the conditions required for the optimum efficiency of a cationic urea-formaldehyde resin. At the point of addition of the resin, it was found that the wet strength was favored by a low pH and the absence of sizing materials. Following resin addition, longer contact time of the resin with the pulp was found to decrease the plugging of the felt with resin. These longer contact times can be obtained practically since the action of the jordan was not found measurably to reduce the wet strength obtained. Reduced maintenance costs can be obtained at a higher pH on the machine, though with a reduction in the wet strength.

Optimum efficiency in the use of a wet-strength resin requires the understanding and control of the many factors influencing the resin performance. Such variables as the type of pulp employed, the freeness, and the presence of minerals or cooking and bleaching residues are not generally controllable for purposes of obtaining improved wet-strength resin performance. Many other variables, affecting conditions at the point of addition of the resin and subsequent to this point, can be altered within moderate limits to improve the wet strength. Several of these variables have a pronounced effect upon such important items as felt life, wire life, and general maintenance costs.

The present study represents an effort to determine the effect of the various controllable variables upon wet-strength resin performance and over-all production costs. Several different commercial cationic urea-formaldehyde resins of widely varying characteristics were employed in this work. The results are thought to be generally indicative of the effect of certain variables upon the performance of many present-day wet-strength resins.

PERTINENT FACTORS AT POINT OF ADDITION

The condition of the pulp at the time the resin is added affects the degree of wet strength obtainable in the finished paper. The most important feature at this

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Table I. Effect of pH at Point of Addition, Wet Tensile, Kg./In.

pH	Alum	H_2SO_4	HCl
2.5	...	5.60	5.90
3.5	...	5.94	5.52
4.5	6.28	5.60	5.42
5.5	5.72	5.72	5.16
6.5	4.84	4.98	5.06
7.5	4.70	4.90	5.02
8.5	5.06	5.12	4.62

ont is the pH. If the pH is low at the point of addition, the wet strength is benefited. Another important factor is that the pulp at the point of resin addition should be free from surface treatments such as rosin or wax sizes if optimum wet-strength results are to be obtained. Consistency has been shown (*1*) to have a moderate effect favoring higher consistencies for better performance, and temperature has been demonstrated to be of relatively little importance at temperatures between 35 and 120°F.

Laboratory experiments were conducted to study the effect upon wet strength of the pH of the pulp at the point of mixing with the resin. Southern kraft pulp, beaten to a freeness of 550 (Schopper-Riegler), was diluted to a consistency of 0.25%. Small portions were withdrawn from a large supply of the stock and were treated in the following fashion. The pH was adjusted with alum, sulphuric acid, or hydrochloric acid as desired and, with stirring, 1.5% of the wet-strength resin (on resin solids basis) was added rapidly. The treated stock (800 ml.) was then added to 10 liters of water in a Valley sheet mold, the pH in the sheet mold was adjusted to 4.5 and a sheet formed.

After pressing between blotters at 100 p.s.i., drying was carried out at 230°F. under one blotter and a felt blanket for 5 min. Wet-tensile testing was generally conducted on the next day. Figures presented are averages of five handsheets.

The effect of the pH at the point of addition is shown in Table I for a cationic urea-formaldehyde resin (Plaskon Aminoplast 348-11L). Similar effects were shown to exist for several other commercial wet-strength resins. In a series of runs employing addition of cationic urea-formaldehyde resins in the beater with alum, it was found that generally much less wet-tensile strength was gained when the resin was added before the alum as was obtained when the addition was reversed. In one case, reversing the addition caused the wet burst to rise from 11.3 to 23.5, in another from 10.6 to 16.1.

In actual practice the pH employed at the point of addition may be limited by the materials from which equipment is constructed. An optimum point should be determined between lowered wet strength on the one hand and increased maintenance costs due to corrosion on the other.

Table II. Effect of Order of Addition of Rosin Size and Cationic Urea-Formaldehyde Resin

Treatment		Wet burst
First	Second	
1.75% rosin	None	7
2% UF resin	1.75% rosin	20
1.75% rosin	2% UF resin	12
1.75% rosin	4% UF resin	18

Table III. Effect of pH at the Paper Machine

pH	2.5	3.5	4.5	5.5	6.5	7.5
Wet tensile	7.06	6.44	5.26	4.72	4.04	3.82

When both a rosin size and wet-strength resin are to be used, it is important, at least with cationic resins, that the wet-strength treatment precede the sizing. In Table II are shown wet-burst results derived from laboratory handsheets made from a northern kraft pulp sized with 1.75% rosin before and after the wet-strength resin treatment. While the wet burst was substantially changed by changing the order of addition, the Cobb size test (T 441 m-45) showed the absorptivity not to vary.

IMPORTANT VARIABLES AFTER RESIN ADDITION

The wet strength obtained in the finished paper is affected by the conditions prevailing after the resin is added to the pulp. These conditions, which include the amount of refining and the elapse of time after resin addition and also the pH on the paper machine, have an effect upon felt and wire life and are important economically.

It has been pointed out (*1*, *2*) that beating after resin addition causes a loss in wet strength. The presumption has been made (*2*) that redistribution of the resin to newly exposed surfaces created by beating does not readily take place. While some decrease in wet strength probably results from passing a resin-treated pulp through a jordan, a carefully controlled experiment failed to show this effect. In fact, when the resin was added before the jordan rather than after, the wet-tensile strength rose from 4.10 to 4.20 kg. per in.

It would appear that while the scraping or abrading action of a beater affects wet-strength resin action adversely, the effect of the cutting action of a jordan is not so pronounced.

The length of time that the pulp is in contact with the resin has been shown (*1*, *2*) to have a moderate influence on wet strength. While it appears that excessive periods of time should be avoided, very short contact time can reduce the wet strength also. From between 10 min. to several hours seems ideal for optimum results.

The time of contact of the resin with the pulp appears to have an important effect on felt life. Longer contact times favor less plugging of the felt. In one case it was found that the use of a cationic urea-formaldehyde resin in the headbox, with very short contact time, lowered the life of the felt from a normal of 2 to 3 weeks (without resin) to 2 days. By adding the resin just after beating and gaining about 2 hr. contact time, the plugging of the felt by the resin appeared entirely eliminated.

The well-known importance of the pH at the wire on wet strength has been studied. Typical data, based on laboratory handsheets and shown in Table III, show the variation in wet tensile with the pH in the wet web.

It should be noted that considerable wet strength can be obtained even at the neutral point. Since corrosion, and its attendant high wire and maintenance costs, also varies with acidity, it becomes important to determine the optimum pH for the lowest over-all wet-strength cost.

CONCLUSIONS

Optimum conditions for the use of a wet-strength resin at the lowest possible cost can be determined through a study of the more important variables. Low pH at the point of addition and on the machine favor high wet strength but increase maintenance costs. Resin addition should be made after beating and may be made before jordanning. Longer contact time of the resin with the pulp favors increased felt life.

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Received Jan. 2, 1952. Presented at the 37th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1952.

The Chemical Composition of the Bast Fibers of Douglas-Fir Bark

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Bast fibers from Douglas-fir bark were examined for their chemical composition. The extractive content was found to be 13.5%, which is low when compared with an extractive content of over 40% in the cork fraction of this bark. The bast fibers appear to be a lignocellulose material with a high lignin content and a corresponding low holocellulose content. At least three different "lignin" materials are present in the bast fibers. The cell wall of the bast fibers shows the presence of concentric rings or layers. A central cavity or lumen appears to contain living protoplast. Pits terminating in the lumen are also in evidence. The fibers are surrounded by a matrix of a reddish-brown phenolic acid. This material is responsible for the relatively high lignin content of the fibers.

The bark from Douglas-fir, *Pseudotsuga taxifolia* (Poir.) Britt., is being commercially separated into bast fibers, cork, and an amorphous fine powder. The chemical nature of the cork was described previously (*6*). The present article describes the findings of an experimental investigation of the chemical composition of the bast fibers.

Douglas-fir bast fibers are short, sharply pointed, spindle-shaped particles of a red-brown color. Their largest diameter is such that they will pass through 40 or 60-mesh screens. A small portion normally may pass through a 100-mesh screen. Other physical properties of the fibers that are pertinent to their use as fillers and in the plastics industry have already been described (*2, 13*).

Figures 1, 2, and 3 are photomicrographs of thin bark sections, which illustrate the general appearance and position of the bast fibers in the bark. Figure 4 shows a cross section of a single bast fiber.

Microscopic examinations of the fiber structure in bark sections reveal the presence of concentric rings or layers in the cell wall. A central cavity or lumen appears to contain living protoplast. Pits terminating in the lumen are also in evidence. The fiber is surrounded by a wall or matrix of reddish-brown lignified material which, under microscopic examination, appears to be removed by dilute alkali solutions. This lignified matrix is responsible for the relatively high lignin content of the fibers.

The bast fiber content of Douglas-fir bark, as determined by grinding and screening methods, is normally between 35 and 48% of the weight of the air-dried bark. Table I gives the fiber, cork, and fines content of four samples of bark. The fines passed through a standard 100-mesh screen; the cork particles were retained on 20, 30, and 40-mesh screens; and the fibers passed through a 40-mesh screen but were largely retained on 60 and 100-mesh screens. The losses reported consisted almost entirely of fines lost as dust during the screening operations.

Table I. Percentage Physical Products from Bark
Values Based on Air-Dried Weight of Materials

Sample	*Fiber*	*Cork*	*Fines*	*Loss*
No. 1, 110–260 yr.	36.5	41.5	17.8	4.2
No. 2, 80–95 yr.	47.8	33.4	15.5	3.3
No. 3, Random	35.4	32.2	18.2	14.2
No. 4, Random	41.2	24.8	29.0	5.0

The fibers used for chemical analysis were obtained from trees ranging from 110 to 260 yr. in age that had been felled 1 mo. prior to sampling. Equal quantities of bark, taken from top and bottom sections of the trees, were ground in a Gruendler hammer mill, air-dried, and then screened in a Rotap shaker. All fractions larger than 40-mesh were reground in a Sprout-Waldron attrition-type mill and rescreened. The fibers were obtained in an almost pure state by stirring the crude fiber fraction in five times its volume of distilled water at room temperature. By virtue of their high specific gravity, the fibers readily sank to the bottom of the container, whereas cork and other impurities remained on the surface and were skimmed off. A small quantity of a wetting agent aided the separation. The purified fibers were then filtered off on a large Buchner funnel, air-dried, and placed in sealed jars for storage.

BAST FIBER ANALYSES

The extractives from Douglas-fir bark have been described in previous reports from this Laboratory.

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Table II. Extractive Content of the Bast Fibers

rentages Based on the Oven-Dry Weight of Unextracted Fibers

Solvent	Per cent	Nature
ex ne	1.59	Light yellow wax
n ene	0.95	Brown wax
hyl ether	0.38	Dihydroquercetin
ot water	9.61	Tannin, carbohydrates, etc.
hanol	0.96	Phlobaphene
Sum of five extractives	13.49	

he present study, quantitative solubility determinations were made on the bast fibers with hexane, nzene, ethyl ether, hot water, and ethanol, successively in that order. The results are given in Table II. hey indicate that the bast fibers are relatively far lower in extractives, particularly in dihydroquercetin nd waxes, than is the cork fraction of Douglas-fir ark (*6*). Obviously, it would not be economically ssible to utilize the fiber fraction as a commercial urce of these substances.

The over-all percentage composition of the bast bers, with the exception of the holocellulose, was determined by TAPPI Standard Methods (*13*) for wood nalysis and is presented in Table III. The attempts prepare holocellulose by the monethanolamine-hlorination procedure, T 9 m, were rendered unsuccessful by filtration difficulties; the method ultimately sed is described in a subsequent paragraph. For ke of comparison, analyses of Douglas-fir wood, taken om the literature, are included in the table. The ata indicate that the bast fibers may be a lignocellulose material with a composition similar to that of ood. The higher lignin content of the bast fibers nd the lower methoxyl group content of this lignin, owever, are notably dissimilar from those found in he wood.

Table III. Percentage Analysis of Bast Fibers and Douglas-Fir Wood

Values Based on Oven-Dry Unextracted Materials

	Fiber	Wood (4)
Ether soluble	2.92	1.32
Alcohol soluble	8.65	5.46
Hot water soluble	2.58	2.82
Sum of three extractives	14.15	9.60

Values Based on Oven-Dry Extractive-Free Materials

Ash	0.60	0.17
Lignin	44.80	30.15
Holocellulose	54.58	71.40
Pentosans	8.62	10.11
Methoxyl group	3.89	4.75
Acetyl group	2.39	0.59 (*10*)
Uronic acid anhydride	4.62	2.80 (*10*)
Methoxyl on lignin	7.16	15.20 (*10*)

olocellulose Procedure

An attempt was made to prepare holocellulose by a odification of the Jayme method employing sodium hlorite and acetic acid reagent (*8, 9, 16*). A series determinations were made with duplicate 2.5-gram mples of extractive-free bast fibers (here, as elsehere in this article, fibers prepared in accordance with APPI procedure T 12 m-45); these samples were bjected to a different number of treatments with odium chlorite and acetic acid. Using this method, he bast fiber samples were placed in a 250-ml. Erlenmeyer flask with 160 ml. of water, 10 drops of glacial acetic acid, and 1.5 grams of sodium chlorite. The flask was then placed in a hot water bath maintained at 70 to 80°C. for 1 hr. At the end of this time, like amounts of sodium chlorite and acetic acid were added. These additions were repeated each hour for the number of times noted in Table IV. Upon completion of the treatments, the flask was removed from the water bath and cooled to room temperature before the contents were filtered on a sintered-glass crucible. The holocellulose was washed with ice water and finally with acetone to facilitate drying to constant weight in a vacuum oven at 50°C. If the holocellulose product was dried at 105°C., it hardened to such an extent that a subsequent lignin residue determination was difficult to make. The data in Table IV show that if an attempt is made to reduce the lignin content of the holocellulose product below 6%, degradation and loss of carbohydrate matter occur.

Extraction with 1% Sodium Hydroxide Solution. When extractive-free bast fibers were extracted with 1% sodium hydroxide solution for 1 hr. in a boiling water bath, there was a loss in weight of 31.35%. The alkali removed about one-half of the lignin, 21.9% of the pentosans, and 56.7% of the polyuronides. After the removal of these constituents that interfere with the holocellulose isolation, the alkali-extracted fibers lent themselves to complete delignification by either the sodium chlorite or the chlorine-ethanolamine procedure. Analytical data obtained from these fibers are given in Table V. The "holocellulose" isolated after alkali extraction was found to contain 77.8% alpha-

Table IV. Percentage Chlorite Holocellulose Determinations

Values Based on Oven-Dry Weight of Extractive-Free Fibers

Test No.	Treatment	Holocellulose product	Lignin in holocellulose product	Holocellulose product corrected for lignin	Total lignin plus holocellulose
1	Four treatments, cooled to room temperature and filtered	61.42	7.35	56.90	100.98
2	Four treatments, held at room temperature 24 hr. before filtering	59.16	6.66	56.08	100.88
3	Four treatments, held at room temperature 48 hr. before filtering	57.78	5.55	54.58	99.38
4	Six treatments, cooled to room temperature and filtered	55.26	5.05	52.47	97.27
5	Six treatments, held at room temperature 24 hr. before filtering	52.35	2.42	51.07	95.87
6	Two treatments, cooled to room temperature, filtered, followed by two more treatments, cooled to room temperature and filtered	58.33	5.42	55.15	99.95

cellulose, 1.6% beta-cellulose, and 20.6% gamma-cellulose.

Sugar Components of the Holocellulose. A qualitative, paper chromatographic analysis, according to the Gordon procedure (*5*), was applied to the hydrolyzate from Klason lignin determinations on extractive-free fibers. The hydrolyzate was prepared for the test by first neutralizing with barium carbonate, then filtering off the precipitated barium sulphate. The filtrate was evaporated to a thin sirup, treated with alcohol to precipitate the barium uronate, and filtered. Finally, the alcohol was distilled from the sugar-containing filtrate. The residue of sugars was made up to volume with water and tested, along with a known sugar mixture containing glucose, galactose, mannose, arabinose, and xylose.

Table V. Percentage Analyses of Bast Fibers Extracted with 1% NaOH

Values Based on Oven-Dry Weight of Extractive-Free Bast Fibers

Material	*Alkali-extracted fiber residue*	*Alkali soluble*
Extractive-free bast fibers	68.65	31.35
Lignin	22.79	22.01
Pentosans	6.53	1.89
Uronic acid anhydride	2.00	2.62
Acetyl, hexosans, etc. (by difference)	...	4.83
Holocellulose (chlorite)	46.54	
Alpha-cellulose	36.20	
Beta-cellulose	0.74	
Gamma-cellulose	9.60	
Holocellulose (chlorine-ethanolamine)	45.50	

Glucose, galactose, xylose, and mannose or arabinose, or both, were found present. The last two sugars were found at approximately the same positions as on the chromatogram developed for the known sugar solution. Wise has shown that mannose, arabinose, and certain other sugar combinations cannot be readily differentiated by present, paper chromatographic methods (*14*). The presence of mannose was subsequently established by the identification of its insoluble phenylhydrazone.

The above qualitative chromatographic sugar analysis was supplemented by a microbiological assay similar to that of Wise and Appling (*15*). The yeast cultures employed were *Saccharomyces carlsbergensis*, *Torula dattila*, and *Hansenula suaveolens*. Reducing sugar values were determined by the method of Somogyi

Table VI. Percentage Sugars Present in the Carbohydrate Fraction of Bast Fibers

Values Based on Oven-Dry Weight of Extractive-Free Fibers

Galactose	3.54
Mannose	6.31
Glucose	39.83
Xylose	11.03
Arabinose	0.00
Total sugars	60.71

(*11*). The composition of the sugar mixture from the hydrolysis of the bast fibers, as determined in this assay, is shown in Table VI. The fermentation procedures indicate the apparent absence of arabinose.

An analysis of the alpha-cellulose fraction from the bast fiber chlorite-holocellulose gave the composition shown in Table VII.

Lignin Components of the Bast Fibers

Three fractions of "lignin" materials from the Douglas-fir bark fibers were isolated and studied. One fraction was a phenolic acid soluble in 1% sodium hydroxide solution and represented about one-half of the total lignin content of the fibers. A second fraction was obtained by extraction of the fibers with dioxane-hydrogen chloride reagent. A third fraction, the residual lignin on the fibers after the above two extractions, was obtained as Klason or 72% sulphuric acid lignin.

Table VII. Percentage Composition of Alpha-Cellulose from Bast Fibers

Values Based on Oven-Dry Weight of Alpha-Cellulose

Ash	0.24
Lignin	0.27
Mannose	1.04
Xylose	0.51
Galactose	0.00
Glucose (by difference)	97.94

Phenolic Acid. Solubility of the phenolic acid was not materially greater in strong alkalies than in weak alkalies, as is shown by the data in Table VIII. These values were obtained by extracting five samples of fibers, each weighing 1.5 grams, with 150 ml. of alkali in 250-ml. flasks in a boiling water bath for 1 hr. Upon removal from the water bath, each sample was filtered on a tared, sintered-glass crucible, washed with distilled water, then with 25 ml. of 5% acetic acid, and finally with distilled water until the washings were free of acid. The residue was washed with acetone and ether before drying in a vacuum oven. Lignin determinations of the dry residual fiber were made by the 72% sulphuric acid method. It is apparent from the data that the phenolic acid is easily removed with dilute alkali.

Table VIII. Percentage Solubility in Different Concentrations of Alkali

Values Based on Oven-Dry Weight of Extractive-Free Fibers

Sodium hydroxide solution	*Insoluble residue*	*Lignin in insoluble residue*	*Dissolved lignin*	*Dissolved cellulose*
0	...	44.80	...	...
1	68.65	22.79	22.01	9.34
5	64.13	21.10	23.70	12.17
10	64.60	20.87	23.93	11.47
15	64.97	20.48	24.32	10.71
20	63.89	20.47	24.33	11.78

For subsequent investigations of the properties and nature of the phenolic acid, the extractive-free fibers were heated with 1% sodium hydroxide solution at the temperature of a boiling water bath for 1 hr. The alkaline solution was filtered from the fibers and made acid to litmus with dilute hydrochloric acid. The precipitate was then washed with distilled water, dissolved in dioxane, and after drying over anhydrous sodium sulphate, reprecipitated by pouring into a large volume of ethyl ether under agitation. Follow-

g this, it was air-dried, washed with hexane, and d for 3 hr. in a vacuum oven at 60°C.

The dry, light-brown, amorphous powder gave a ark red color with dilute alkalies. It was only ightly soluble in dioxane, alcohol, acetone, pyridine, thyl acetate, although the moist precipitate when isolated was completely dispersed in dioxane or one. No color reaction was obtained with phloroinol and hydrochloric acid. Methoxyl group ntent was 4.34%. A 72% sulphuric acid lignin rmination gave a yield of 79.4% "lignin," the methyl group content of which was 4.28%. It was concluded that no carbohydrate matter was present in phenolic acid, and that the loss in weight was due solubility in the sulphuric acid solution.

xidation of the phenolic acid to vanillin with nitrobenzene in sodium hydroxide solution was carried out accordanee with the procedure of Freudenberg, *(3)*. The yield of vanillin, quantitatively determined by the method of Hibbert and Tomlinson (*7*), 1.63%. This indication that the phenolic acid does not resemble lignin, which has a substantial amount vanillin present in the molecule, is also in agreement with its low methoxyl content of 4.3%.

ig. 1. Cross section of Douglas-fir inner bark showing position of the bast fiber

1, Wood or xylem. 2, Cambium region. 3, Functioning hloem. 4, Inactive phloem. 5, Bast fiber. 6, Phloem parenchyma cell. 7, Phloem ray.

Methylation studies on the phenolic acid were carried out using diazomethane (*1*) and dimethyl sulphate in alkaline solutions. The results of these studies are summarized in Table IX. On the assumption that the phenolic acid is monocarboxylic and contains 5.3% carboxyl groups, its molecular weight is 850 and the molecule contains approximately one methoxyl group, four phenolic groups, and two aliphatic hydroxyl groups.

Fig. 2. Tangential section of Douglas-fir bark showing irregular, spindle shapes

1, Bast fiber; neighboring fiber to the right shows exposed cavity or lumen. 2, Horizontal resin canal. 3, Inner active phloem.

Elementary analysis gave 54.12% carbon and 5.33% hydrogen. Using these values and a molecular weight of 850, the following empirical formula was calculated for the phenolic acid:

HO	OH
$HOC_{36}H_{35}O_{13}$	OH
HO	OCH_3
HO	COOH

Infrared absorption spectrum confirmed the presence of the carboxyl group in this phenolic acid and served to show a similarity of the acid to the phlobaphene in the alcohol extractive from the bast fibers. Both the phenolic acid and the phlobaphene spectra displayed little or no carbonyl absorption. An ultraviolet absorption spectrum of the phenolic acid showed the maximum absorption peak in the 280 mmu region. This behavior has been found common to many lignin, tannin, and phlobaphene preparations.

Dioxane-Hydrogen Chloride Lignin. The extractive-free bark fibers were extracted in alundum crucibles in a Soxhlet extractor for 9 hr with dioxane which contained 0.4% hydrogen chloride. At the end of this period, the solvent remained colorless. The amount of lignin extracted was 10.8% of the weight of the

extractive-free fibers. A similar extraction with dioxane without the hydrogen chloride catalyst gave a yield of only 1.7% extract. The lignin was recovered from the dioxane as a voluminous light-brown powder

Fig. 3. Radial section of Douglas-fir bark

1, Wood or xylem. 2, Cambium. 3, Bast fiber.

by precipitation with water. It was purified by redissolving in dioxane, reprecipitating with ethyl ether and washing with hexane. The dry powder was soluble in dilute alkalies, alcohol, acetone, and ethyl acetate.

Table IX.

Methylation of Phenolic Acid

	Methoxyl, %	*Increase in methoxyl, %*
Phenolic acid	4.3	...
Diazomethane methylated phenolic acid	22.4	18.1
	21.8	17.5
Dimethyl sulphate methylated phenolic acid	26.0	21.7
Dimethyl sulphate and diazo methane methylated phenolic acid	29.3	25.0

Functional Groups in Phenolic Acid

	Per cent	*No. in molecule*
Methoxyl	4.3	1.18
Carboxyl	5.3	1.00
Phenolic hydroxyl	8.3	4.14
Aliphatic hydroxyl	4.2	2.10

It had a methoxyl content of 14.3%. After treatment with hot 1% sodium hydroxide, the methoxyl group content was 13.2%. When subjected to a lignin determination with 72% sulphuric acid, 87.6% was recovered as lignin and the product had a methoxyl content of 13.1%. Upon methylation with diazomethane, the methoxyl content of the dioxane-lignin was increased to 21.6%, while methylation with dimethyl sulphate in sodium hydroxide solution gave a product with 27.6% methoxyl. The latter product after further methylation with diazomethane had 29.3% methoxyl, indicating a carboxyl acid group content of 2.5%.

Residual lignin. Extractive-free bark fibers were next treated successively with 1% sodium hydroxide solution, dioxane-HCl reagent, and 72% sulphuric acid to determine the "lignin" yields obtained with each reagent. The product yields were 22.0, 11.8, and 11.0% respectively. The phenolic acid extracted with sodium hydroxide contained 4.3% methoxyl groups, the dioxane-lignin contained 13.5% methoxyl groups, and the residual lignin isolated by the 72% sulphuric acid procedure contained 11.1% methoxyl groups. These data indicate that the extractive-free bast fibers contain at least three different "lignin" fractions.

SUMMARY OF RESULTS

Potentialities for Douglas-fir bark utilization have been found in the extractives removed by neutral sol-

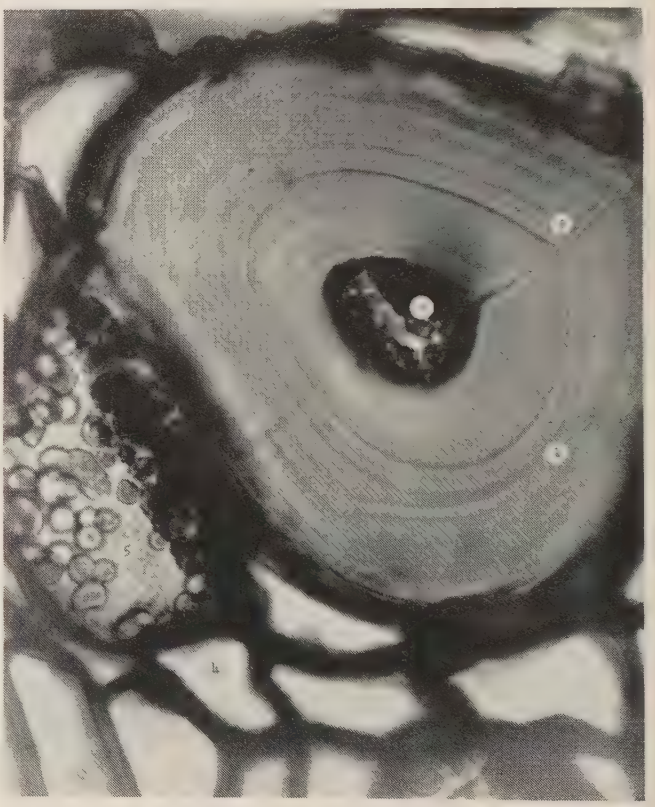

Fig. 4. Cross section of Douglas-fir bark bast fiber

1, Ring structure. 2, Pit. 3, Cell cavity or lumen showing living protoplast. 4, Crushed sieve cells. 5, Phloem parenchyma.

vents, and in the structural components separated by physical means. About 35 to 48% of the air-dried bark is composed of short, spindle-shaped bast fibers. These have been found to possess an outside wall or

rix of a reddish-brown phenolic acid which is soluble dilute alkali solutions. The fibers have a high specigravity, a thick layered or ring-structure cell wall, a cell cavity.

Extractive contents of the fibers were obtained by cessive extractions with hexane, benzene, ethyl her, hot water, and ethanol. The following yields were obtained on an oven-dry basis: hexane, 1.59%; benzene, 0.95%; ethyl ether, 0.38%; hot water, 9.61%; ethanol, 0.96%. The relatively low sum of these extractives (13.5%) indicates that it would not be feasible to utilize the fibers as a source of extractives, particularly wax and dihydroquercetin. Holocellulose determinations on the extractive-free fibers with chloride dioxide reveal that degradation of the cellulose occurs when attempts are made to obtain holocellulose with less than 5.4% lignin. It was found that after the bark fibers have been extracted with a dilute alkali solution, a holocellulose fraction containing from 0.1 to 5% lignin could be obtained. This fraction cannot by definition be correctly called "holocellulose," since 33% carbohydrate material was removed by the alkali along with 22.0% lignin. The carbohydrate material removed by the alkali was found to consist of 1.89% pentosans, 2.62% uronic acid anhydride and 5.49% hexosans. The "holocellulose" isolated after the alkali extraction contained 77.8% alpha-cellulose, 1.6% beta-cellulose, and 20.6% gamma-cellulose. The following composition of the alpha-cellulose was determined: ash, 0.24%; lignin, 0.27%; mannose, 0.04%; xylose, 0.51%; galactose, none; glucose, 97.94%. An analysis of the total carbohydrate of the extractive-free fiber showed the following: galactose, 1.54%; mannose, 6.31%; xylose, 11.03% by fermentation or 9.90% by pentosan determination; arabinose, none; and glucose, 39.85%, based on the weight of extractive-free fiber. Three fractions of "lignin" materials from the fibers were isolated and studied. The fraction of "lignin" removed by 1% sodium hydroxide represented 49% of what appeared as Klason lignin, based on the whole extractive-free fibers. This easily removed "lignin" material was found by infrared and chemical analysis to resemble a high molecular weight phenolic acid rather than what is generally designated as lignin. A functional group analysis by methylation revealed that this phenolic acid contained: methoxyl, 4.3%; carboxy group, 4.9–5.3%; phenolic hydroxyl, 8.3%; and alcoholic hydroxyl, 4.2%. On this basis, one building unit of molecular weight, 850–918, would contain one carboxyl, one methoxyl, two alcoholic hydroxyl, and four phenolic groups. Based upon a molecular weight of 850, functional group data, and the elementary composition (54.12% carbon, 5.33% hydrogen), an empirical formula was proposed for the phenolic acid in Douglas-fir bark fiber.

Infrared studies confirmed the presence of the carboxyl group in this phenolic acid and served to show the similarity of the acid to the phlobaphenes isolated from the Douglas-fir bark bast fibers. An ultraviolet absorption spectrum of the sodium hydroxide soluble phenolic acid showed the maximum absorption peak in the 280 mmu region. This behavior has been found to be common to many lignin, tannin and phlobaphene preparations. Oxidation of the phenolic acid from the bast fibers yielded 1.63% vanillin. Evidently, the phenolic acid does not resemble lignin in respect to the presence of a vanillin nucleus. This is in accord with the infrared spectrum which shows little indication of the presence of carbonyl groups. The low methoxyl content of the bark fiber phenolic acid is comparable to the methoxyl content of the phlobaphene which was found to contain 2.77% methoxyl. This relationship to phlobaphene was further displayed when the infrared spectra of the two materials were found to be almost identical. Both spectra displayed strong carboxyl or ester absorption, and little or no carbonyl absorption.

The lignin extracted from Douglas-fir bark fibers by means of dioxane-HCl solution was obtained in a 10.8% yield. An 11.8% yield, based on the weight of oven-dry, extractive-free fibers, was obtained when the fibers had been previously extracted with 1% sodium hydroxide solution. These yields are equivalent to about 24% of the total "Klason lignin" in the extractive-free fiber. Dioxane lignin was found to possess a greater similarity to softwood native lignin than to the phenolic acid of the fibers. By methylation studies, its functional groups were identified as follows: methoxyl, 14.3%; alcoholic hydroxyl, 4.4%; phenolic hydroxyl, 3.2%; carboxyl group, 2.5%. The preparation of a phenylhydrazone derivative and infrared absorption show the presence of a carbonyl group in the dioxane-HCl lignin. This dioxane lignin was the only fraction of the bark fiber lignins which decisively exhibited the presence of carbonyl groups.

The 72% sulphuric acid or Klason lignin amounted to 44.8% of the extractive-free bark fibers and represented the total lignin content as it is conventionally determined. Its spectra showed it to be similar to the other two preparations but to possess decreased functional group contents. Therefore, the "lignin" in the bast fibers is not a homogeneous material, and further investigation into its chemistry should be performed on purified homogeneous fractions.

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Received July 29, 1952. A condensation of the thesis presented by Harry J. Kiefer in partial fulfillment of the requirements for the Ph.D. degree in Chemistry at Oregon State College, July, 1951.

Performance of Paper Machine Wet Felts

II. Further Studies of the Plugging of Felts

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The wet felts of papermaking machines may become plugged or occluded by deposits which accumulate on and adhere to the wool fibers. This often occurs before mechanical wear or microbiological deterioration have much affected felt performance, although it may be associated with some aspects of microbiological activity within the felts. To determine the degree to which various felts were plugged, the following techniques were used: (1) samples of felt were embedded in plastic, sectioned with a microtome, the sections stained and examined microscopically; (2) the amount of time required for a given amount of water to pass through a sample of felt under standardized conditions was determined; (3) the amount of water absorbed by a felt sample of standard size, and the amount retained after passing the wet sample through a wringer under constant pressure were measured. A combination of these methods gives more accurate information than any one of them alone. A number of techniques were devised to determine the nature and composition of the material causing plugging: (1) plugged felts were extracted with various solvents to obtain resins and similar materials; (2) felt samples were ashed to determine mineral content; (3) samples were blendorized in a Waring blendor to remove deposits from the fibers. These were subsequently separated, and the deposits subjected to various tests to determine their nature. As a result of these tests it was found that the material causing the plugging might consist mainly of resins, mainly of filler material or mainly of fragments of scales from the outside of the wool fibers. In many felts, the plugging material was a composite of different substances, with considerable variation in make-up from mill to mill according to the type of pulp processed and the kind of paper produced. Various attempts were made to determine the role played by bacteria in the plugging of felts. These involved culturing of plugged material to determine the number and kinds of bacteria in it, partition chromatography of new and used felts in an attempt to detect bacterial by-products as well as degradation products of the felts, and the inoculation of felt samples with bacteria. It seems unlikely that aggregations of bacteria are solely responsible for large amounts of plugging, but the presence of bacteria may increase the amount of plugging caused by other materials.

PART II is a continuation of the work reported in Part I, entitled "Preliminary Microscopic Observations of the Effect of Microorganisms on the Plugging of Felts" (*2*). The first objective of this study was to establish procedures for determining the amount of plugging and to correlate the percentage of plugging with factors such as interval between washing, amount of filler, amount of size, and pH. Second, the nature and composition of the deposit material causing plugging were investigated. Special attention was given to the possible agents of plugging or those factors which might regulate increased or decreased felt plugging.

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MICROSCOPIC DETERMINATION OF AMOUNT OF PLUGGING

The method of preparing microscopic slides for determining the amount of plugging was described in Part I. Stains other than safranin-o were tried and similar results were obtained with several different stains. The amount of stain absorbed by the felt fibers increased when the felts were deteriorated by bacteria, or by any other agent. However, stains were of limited value for detecting bacteria in these prepared slides of felt sections. The data in this section were derived from approximately 9000 sections of a variety of felts from 30 mills over a period of about 2 years.

The paper mills were arranged in groups according to the type of pulp used and paper produced. In addition to making these correlations between types of mills and individual mills, the felt samples from each mill were studied separately to limit the number of variables. The mills were divided into the following groups and data for felt samples obtained from them are presented in Tables I, II, III, IV, and V:

Groundwood-sulphite	newsprint
Sulphite-soda	writing, typing, bond papers
Sulphite-sulphate	bond, tissue, waxing papers
Sulphate (bleached)	butcher, bag, waxing papers
Sulphate (unbleached)	kraft papers of all kinds

To reduce the variable of length of time the felt was in use, an arbitrary index of plugging was derived. This was computed by dividing average percentage of plugged area by the number of days the felt had been in use. This is a simplified factor which does not take into consideration a number of variables involved in the complex problem as a whole. It is used in the analysis of the data as an approach which it is felt reduces some of the variability. It should be noted, though, that continued running of a felt for a longer period of time may account for a reduction in the plugging index. If a felt plugs rapidly and a mill continues to use it with acceptance of a decreased performance, the plugging index will become lower and lower the longer the felt is run. Thus a low plugging index does not necessarily mean a low amount of plugging material in the felt.

Effect of Interval Between Washing

Interval between washing is the length of time in days between felt washing operations. In one of the newsprint mills, mill no. 4, the data demonstrate that probably there will be less plugging in first press felts if the felts are washed more frequently (Fig. 1). Figure

includes data from machine no. 7 only. This same correlation existed in a bleached sulphate mill and is shown in Fig. 2. No such correlation could be drawn from the balance of the data. It is very possible that

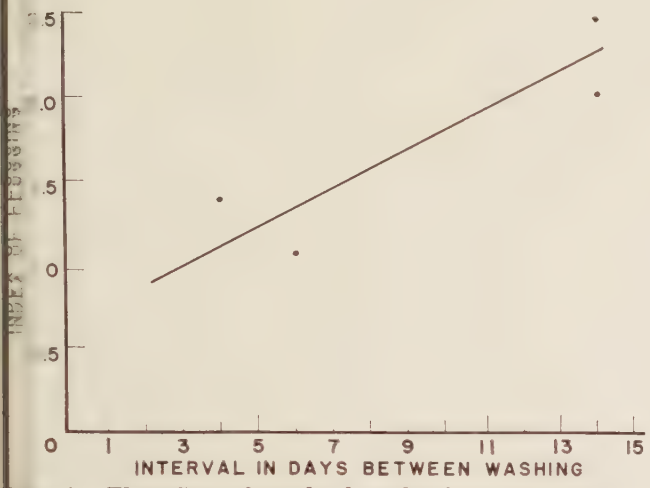


Fig. 1. The effect that the length of interval between washing has on the amount of plugging in a newsprint felt

The time between the last washing and the end of the life of the felt is important, but this information was not available for the study.

Effect of Amount of Filler.

In newsprint mill no. 3 the addition of filler did not account for any increase in the amount of plugging. This comparison was based on two different machines and only two samples from each mill. In the sulphite-soda mills there was some indication of a correlation between index of plugging and amount of filler (Fig. 3). The relative amounts of size might influence the part that fillers play in increasing the amount of plugging as

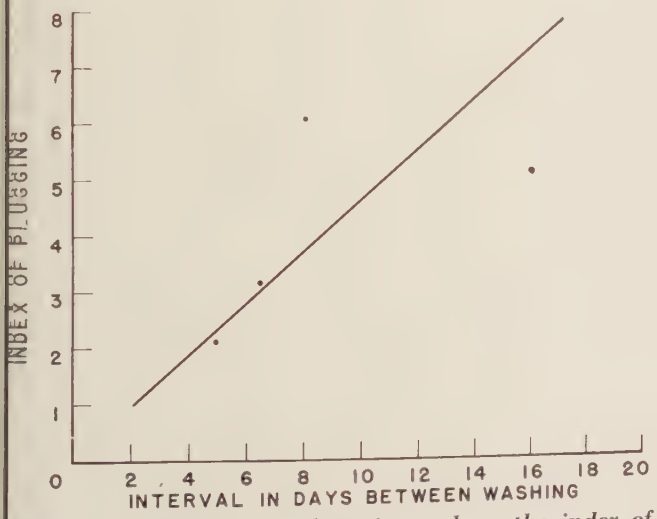


Fig. 2. The effect of washing interval on the index of plugging in a bleached sulphate mill

demonstrated by the first press felt on machine no. 4. Two felts removed from the second machine of a bleached sulphate mill had a difference in the amount of plugging which may be accounted for by the use of filler or

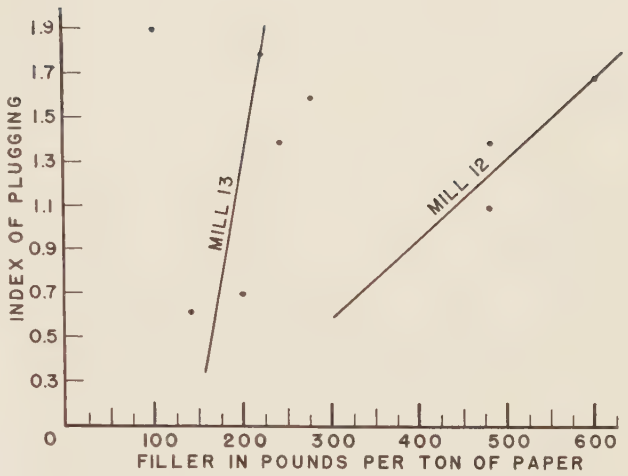


Fig. 3. The effect of the amount of filler on the index of plugging in a sulphite-soda mill

by the change in washing interval (Table IV). In the data on felts from a sulphate-sulphite mill, there was no correlation between the amount of filler and the index of plugging. The variability in this mill is demonstrated in Fig. 4.

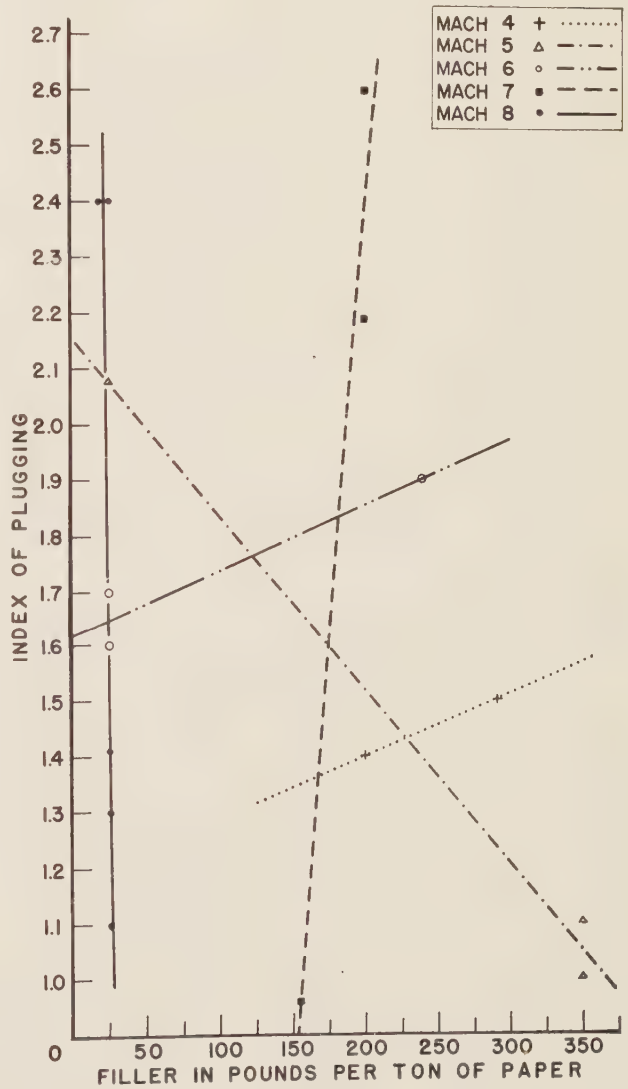


Fig. 4. The effect of the amount of filler on the index of plugging in a sulphate-sulphite mill

Table I. The Data Obtained from Microscopic Examination of Felts from Several Newsprint Mills

Mill No.	*Machine No.*	*Press No.*	*Plugging index*	*Filler per ton of paper, lb.*	*Size per ton of paper, lb.*	*Temp., °F.*	*pH*	*Interval between washings, days*
1	1	2	1.1	none	none	94	4.7	6
1	2	2	2.2	none	none	94	4.7	5
2	1	1	2.5	none	none	104	..	4
3	4	1	0.5	China clay	none	85	5.0	5
3	7	1	1.1	none	none	100	5.0	6
4	1	1	1.1	none	none	94	5.0	8
4	2	2	0.8	none	none	96	5.1	9
4	3	1	1.1	none	none	95	5.1	8
4	4	2	1.1	none	none	94	5.0	7
4	5	2	1.0	none	none	86	5.0	5
4	7	1	1.4	none	none	88	5.1	4
4	7	2	2.9	none	none	89	5.0	3
4	7	1	2.1	none	none	90	5.0	14
4	7	1	2.5	none	none	95	5.0	14
4	7	2	2.0	none	none	94	5.0	14
4	7	2	2.0	none	none	97	5.0	5
4	7	2	2.8	none	none	97	4.9	6
4	7	1	1.1	none	none	95	4.7	6
5	2	2	0.9	none	none	83	5.6	3
6	1	1	1.6	none	none	100	5.3	..
6	5	2	1.7	none	none	107	5.2	..
6	8	1	3.3	none	none	107	5.2	..
6	8	2	1.8	none	none	110	5.2	..
7	6	2	0.5	none	none	110	5.2	..
8	1	2	2.5	none	none	98	5.3	6
8	2	1	5.5	none	none	83	5.2	6

Effect of Amount of Size

In newsprint mill no. 8 the amount of plugging was higher and was due mainly to a high pitch content in the felt. There was no definite indication on the same machine and press that amount of size was critical in causing increased plugging. In the sulphate-sulphite pulp mill no correlation was found between index of plugging and amount of size. Figure 5 shows an inverse relationship between amount of size and plugging.

Effect of pH

The data from a bleached sulphate mill demonstrated an increased amount of plugging with higher pH (Fig. 6). No such correlation existed in any of the other mills investigated.

Summary and Discussion of Microscopic Examinations

Microscopic examination of these sections demonstrated that most felts were actually plugged, some to a large extent after only a short period of use. It showed that the deposit material usually adhered to the fibers and could practically occlude all the openings. The deposit material varied from dark opaque particles to small granular material which resembled bacterial cells and fiber scale particles. There were occasional fragments of felt fibers, wood fibers, resinlike material, and miscellaneous objects. These are shown in Figs. 7, 8, and 9 as contrasted with a new felt in Fig. 10.

Table II. The Data Obtained from Microscopic Examination of Felts from Two Sulphite-Soda Mills

Mill No.	*Machine No.*	*Press No*	*Plugging index*	*Filler per ton of paper, lb.*	*Size per ton of paper, lb.*	*Temp., ° F.*	*pH*
12	3	3	0.3	600	none	63	7.1
12	4	1	1.7	600	none	64	7.1
12	8	1	1.1	480	none	61	7.1
12	8	1	1.4	480	none	62	7.0
13	1	1	1.0	..	..	77	4.3
13	1	1	0.6	140	24	86	..
13	1	2	1.0	200	22	77	4.7
13	2	1	1.6	276	20	86	..
13	2	2	1.3	220	22	77	..
13	2	3	1.0	280	20	77	4.7
13	3	1	0.7	200	22	77	..
13	3	1	1.8	220	22	77	4.7
13	4	1	1.9	100	29	68	4.3
13	4	1	1.4	260	18	77	4.3
13	4	2	0.9	250	21	68	4.3
13	4	2	1.2	260	18	77	4.7
13	4	3	0.7	260	18	77	4.7

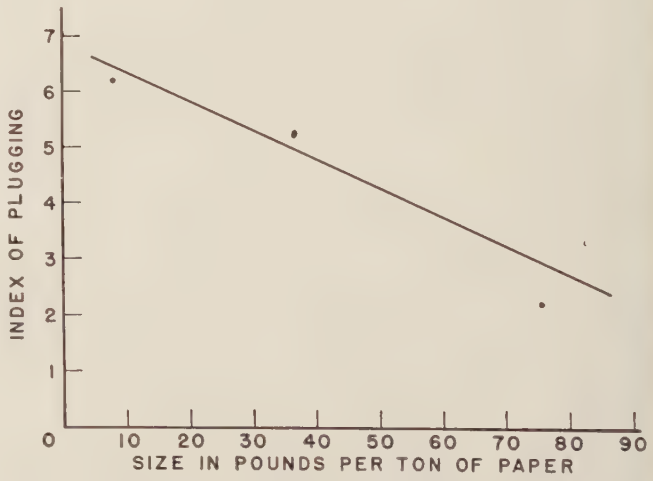


Fig. 5. The effect of the amount of size on the index of plugging in a bleached sulphate mill

The visual percentage plugging estimates were verified by planimeter readings. Because they were estimates it is possible that the readings were not exactly consistent. The felt samples were small enough so that they could be nonrepresentative of the plugging condition in the felt as a whole. The variation from place to place in a felt is shown in Figs. 11 and 12.

The percentage plugging observed in these felts was based on the material in the interfiber spaces and not

Table III. The Data Obtained from Microscopic Examination of Felts from a Sulphate-Sulphite Mill

Mill No.	*Machine No.*	*Press No.*	*Plugging index*	*Filler per ton of paper, lb.*	*Size per ton of paper, lb.*	*Length of interval between washing, days*
14	1	1	1.3	none	23	....
14	3	1	4.7	none	45	....
14	3	1	3.8	150	45	continuous
14	3	2	1.1	150	50	continuous
14	3	3	0.7	none	50	3.5
14	4	1	1.5	300	25	continuous
14	4	1	1.4	200	80	continuous
14	4	2	0.8	300	25	3.5
14	4	3	1.1	300	25	3.5
14	4	3	1.1	200	20	3.4
14	5	1	1.0	300	20	...
14	5	1	1.1	350	20	2.5
14	5	1	2.1	25	25	2.2
14	5	2	0.8	25	25	3.2
14	5	3	0.6	25	25	5.8
14	6	1	1.9	240	20	2.9
14	6	1	1.7	25	25	3.2
14	6	1	1.6	25	25	3.7
14	6	2	1.0	25	25	3.2
14	6	3	0.8	25	25	4.1
14	7	1	0.4	155	15	2.3
14	7	1	2.2	200	25	3.1
14	7	1	2.6	200	25	2.8
14	7	2	1.0	200	25	3.2
14	7	3	0.6	200	25	2.2
14	8	pick-up	0.6	25	25	6
14	8	pick-up	1.4	20	20	2.8
14	8	top	0.9	25	10	2.1
14	8	bottom	1.1	25	25	4.5
14	8	bottom	1.3	25	25	4
14	8	bottom	2.4	20	20	3.5
14	8	bottom	2.4	25	10	3.5

nterthread spaces. The sections embedded by the mills ere selected from open and plugged areas in the felt. he percentage plugging corresponded with the mill tings in most cases.

The most significant factor derived from this phase f the study is the absence of any substantial correlaon between the index of plugging and the amount of dditives such as filler and size. This indicates that me agent such as bacteria could be a controlling factor felt plugging. There were differences in the perntage of plugging dependent on the types of pulp Table VI).

The following general facts were learned from study f these slides:

1. In all mills there was more plugging in the first press felts an in the second and third.
2. The index of plugging was directly correlated with pH in a eached sulphate mill. Results from other mills were variable.
3. There was correlation between the index of plugging and ae length of interval between washing although this situation d not exist in all mills.
4. The effect of filler on plugging was not what was expected. As the amount of filler was increased, there were increases, decreases, and no changes in the amount of plugging. This suggests that the amount of filler is not as important as some agent such as bacteria that has the ability to trap the filler material.
5. The effect of the amount of size on plugging is variable.

The foregoing data, while valuable in determining the amount of plugging, did not yield information on many phases of the problem—information essential to an understanding of the basic factors involved in plugging. It was thought that work with strips of used felt would contribute additional information.

ADDITIONAL METHODS OF DETERMINING AMOUNT OF PLUGGING

Plugging as Shown by Water Passage Tests

A procedure was developed to measure plugging as it influenced the effectiveness of a felt in operation. This method measured the time required for 1 liter of water to pass through 314 sq. mm. of felt. A minimum of

Table IV. The Data Obtained from Microscopic Examination of Felts from a Bleached Sulphate Mill

Machine No.	*Press No.*	*Time in operation, days*	*Plugging index*	*Filler*	*Size per ton of paper lb.*	*pH*	*Length of interval between washing, days*
1	1	7	7.2	none	36	5.0	7.0
1	1	14	6.0	none	36	5.0	14.0
1	1	11	6.1	none	36	5.0	11.0
1	1	24	3.3	none	36	5.0	24.0
1	1	25	3.4	none	36	5.0	25.0
2	1	28	2.5	clay and TiO_2	75.8	4.5	5.6
2	1	25	1.9	none	75.8	4.5	4.2
3	1	26	3.3	none	82.5	4.8	6.5
3	3	85	1.0	none	82.5	4.8	6.5
4	1	6	8.5	none	27	5.0	6.0
4	1	7	6.9	none	none	5.0	7.0
4	1	12	3.3	none	none	5.5	12.0

Table V. The Data Obtained from Microscopic Examination of Felts from Six Unbleached Sulphate Mills

Mill No.	*Machine No.*	*Press No.*	*Plugging index*	*Size per ton of paper, lb.*	*pH*
14	3	1	4.7	45	4.8
16	1	1	5.0	4	6.0
16	1	1	6.4	4	6.0
16	1	1	3.2	4.5	6.0
16	1	1	4.1	3.5	5.8
16	1	1	2.1	3.5	5.9
16	1	1	2.9	3.5	6.0
16	1	1	2.9	4	5.9
16	1	1	6.0	4	5.9
16	1	1	5.1	4	5.9
16	1	2	2.0	4	6.0
16	1	2	3.2	4	6.0
16	1	2	2.1	3.5	6.0
16	1	2	2.5	4.5	6.0
16	1	2	3.2	3.5	5.8
16	1	2	4.0	3.5	5.8
16	1	2	2.1	3.5	5.9
16	1	2	2.5	3.5	6.0
16	1	2	4.2	4	5.9
16	1	2	3.7	4	5.9
16	2	1	4.2	6	5.3
16	2	1	5.0	6	5.3
16	2	1	7.0	6	5.3
16	2	1	4.5	3	5.5
16	2	1	6.3	5.5	5.3
16	2	1	4.8	6	5.3
16	2	1	6.4	7	5.3
16	2	1	6.4	7	5.3
16	2	2	2.1	6	5.3
16	2	2	3.3	6	5.3
16	2	2	3.0	6	5.3
16	2	2	1.0	5	5.5
16	2	2	5.6	5.5	5.3
16	2	2	1.4	6	5.3
16	2	2	3.6	7	5.3
16	2	2	3.9	7	5.3
17	1	1	3.2	8	6.5
17	1	2	2.6	8	6.5
18	1	2	1.3	various	varied
18	1	2	2.5	various	5.3
19	1	1 bottom	2.7	13.4	6.7
20	1	1 bottom	2.0	30?	7.3
20	1	1 bottom	7.0	35	7.3

two samples were tested for each felt. The apparatus for this test consisted of two funnels, each with a top diameter of 205 mm., a rubber stopper fitted into another stopper for holding the test specimen, a wire screen to keep the felt from sagging, a liter volumetric flask, and a stop watch (Figs. 13 and 14).

A liter of distilled water was poured into the upper funnel equipped with a stopper. A stop watch was started and, simultaneously, the plug in the upper funnel removed. The water passed through the felt sample and into the volumetric flask. When the liter of water had passed through the system the watch was stopped and the time recorded. The felt samples were conditioned before testing by soaking for 2 hr. in distilled water. If this was not done, erratic readings resulted. Figure 15 illustrates, in one sulphate mill, the decreased rate of water passage as the wet volume of the deposits is increased (wet volume is a measure of the plugging material removed from a felt sample which was subjected to a Waring blendor for 3 min.).

The water passage method gave consistent results that could be correlated with the extent of plugging in the felt. The time for water passage varied from a few seconds for a new felt to 4 or more hours for used felts.

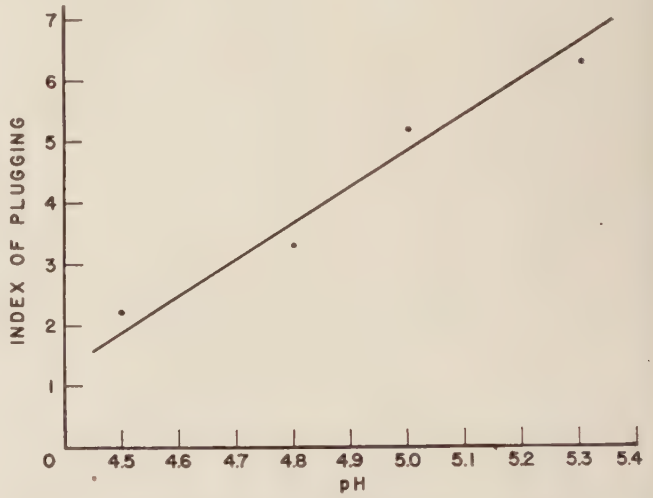


Fig. 6. The effect of pH on the index of plugging in a bleached sulphate mill

Within short periods of time water passage readings on the same sample did not change appreciably, as evidenced on one sample that had average readings of 38, 35, 35, 37, 34, and 37 sec., taken over a 4-hr. period.

Amount of Plugging as Determined by Water Absorption Tests

To supplement the water passage method and possibly obtain a more accurate measure of change in operational effectiveness of a felt, a water absorption test was developed. This test was designed to measure the amount of water absorbed by a felt and the amount given up when it passed through a set of rollers. The method was as follows: a felt sample 6 by 23 cm. was cut from a felt strip, soaked in distilled water for 2 hr., and run through a wringer which was set to apply the same pressure to all samples. It was weighed, and this figure was recorded as wet weight of the felt. It was then soaked in distilled water for 10 sec. and weighed for the second time. The difference between the first and second weighing was the water gain. The sample was sent through the same rollers and weighed the third

Table VI. The Summation of the Plugging Indexes for the Various Types of Paper Mills

Type of pulp	*Type of paper*	*Plugging index*			
		Pick-up press	*First press*	*Second press*	*Third press*
Groundwood-sulphite	Newsprint	..	2.0	1.7	..
Groundwood-sulphite	Toilet tissue	1.1	2.7	..	..
Sulphite	Bond, offset	..	2.4	..	..
Sulphite-soda	Writing, typing, book	..	1.3	1.1	0.7
Sulphite-sulphate	Bond, tissue, waxing	1.0	1.7	0.9	0.8
Bleached sulphate	Butcher, bag, waxing	..	4.8	..	1.0
Unbleached sulphate	Kraft paper	..	4.6	2.9	..

tirae. The difference between the third and second weight was the water loss. The data on water absorption are in Table VII.

The average plots of the wet volume of the deposits

Fig. 7. Section of a used first press felt from a paper machine processing bleached sulphate pulp

This felt contained a total extractive percentage of 34.5. The deposit material is largely size or pitch. 175×.

over water absorption (water gain) show an increase in water gain as wet volume of the deposits decreases (Fig. 16).

The effect of soaking on felt condition was a gradual increase in water absorption. The following comparison was made between a sulphate mill felt at 1 and 2-day intervals:

	Water gain, g.	*Water loss, g.*
Original test	5.6	6.2
After 1 day's soaking	6.1	6.9
After 2 days' soaking	6.6	7.0

Washing of Plugged Felts

To obtain controls for water passage and water absorption the samples used in the above tests were washed. Trials showed that felts could be washed effectively with a detergent soap. It was found that felt samples through which water passed rapidly were not changed appreciably by washing. Felt samples through which water passed slowly changed considerably as shown in Table VIII.

The effect of washing on water gain and loss was shown with the data in Table IX. These were unbleached sulphate mill felts and the samples were washed for 45 min. in 1% Busan.* The wet volume of washed and unwashed samples of the same felt were 0.87 ml. per gram for the unwashed sample and 0.69 ml. per gram for the washed sample.

If the felt sample can be washed to the extent that only an insignificant amount of plugging material remains in the felt, the water passage and water absorption determination are more satisfactory for determining percentage plugging than the microscopic method. In general, these methods of determining plugging can-

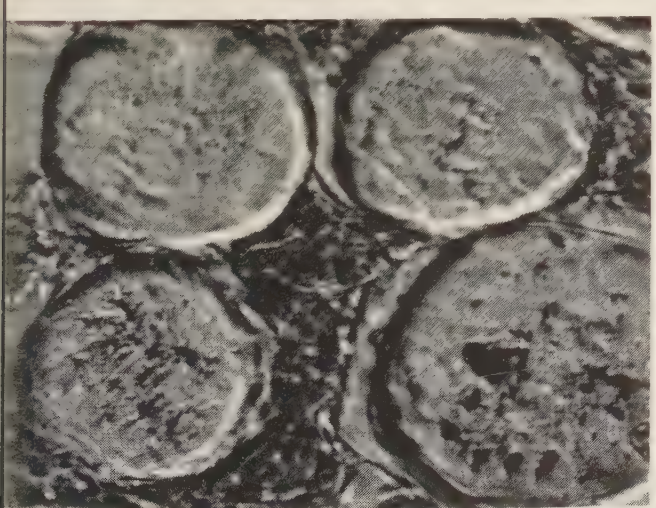


Fig. 8. Section of a used first press felt from a paper machine processing unbleached sulphate pulp. 750×

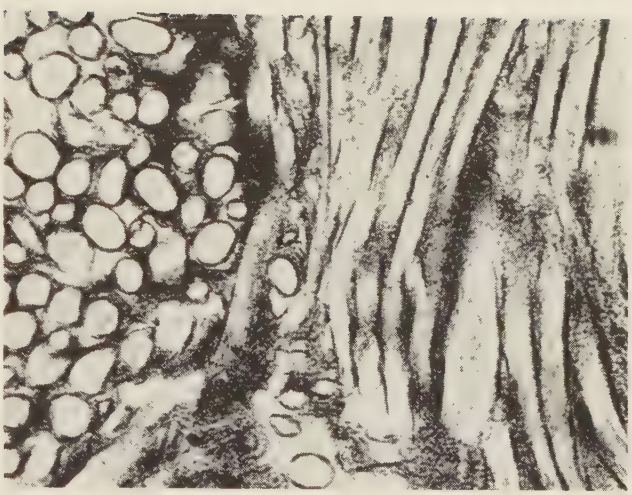


Fig. 9. Section of a used third press felt from a paper machine using sulphite-soda pulp. 175×

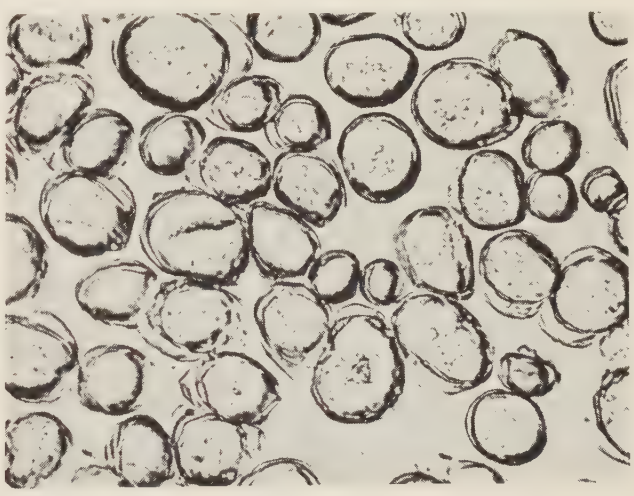


Fig. 10. Section of a new felt. 270×

* Busan, a product of Buckman Laboratories, Inc., is a combination of a mixture of trimethyl octadecenyl and trimethyl octadecadienyl ammonium chlorides (45%), 8-hydroxyquinoline (10%), and inert ingredients (45%).

Table VII. The Data Obtained from the Various Standard Tests Run on Strips of Felt from the Paper Mills

Mill No.	*Press No.*	*Water passage min.*	*Water gain, g.*	*Water loss, g.*	*Ash, %*	*Ether extract, %*	*Alcohol extract, %*	*Ash after extraction, %*	*Wet volume per gram of felt, ml.*	*Dry weight per gram of felt, g.*
7	2	..	..	..	0.5	..	..	..	..	..
8	..	..	..	..	1.4	9.1	4.4	..	..	..
9	1	1.5	4.7	4.9	0.5	..	..	..	0.77	0.04
9	1	..	5.3	4.9	0.7	..	..	..	0.47	0.04
9	1	1.4	6.6	6.7	0.5	..	..	..	0.75	0.08
9	1	1.2	6.9	6.9	0.9	..	..	..	0.96	0.09
9	1	1.5	7.6	8.0	0.7	..	..	..	0.84	0.06
9	1	1.1	5.5	5.7	1.0	..	..	..	0.77	0.06
9	1	2.6	5.1	5.9	0.7	..	..	..	0.87	0.05
11	1	4.1	4.5	4.0	..	..	..	..	0.40	0.20
13	1	..	..	..	5.8	..	..	..	..	..
13	1	..	..	..	3.2	..	..	..	..	..
13	1	..	..	..	3.7	..	..	..	..	..
13	1	..	..	..	3.8	..	..	..	..	..
13	1	..	..	..	3.1	..	..	..	..	..
13	1	..	..	..	4.6	..	..	..	..	..
13	1	..	..	..	7.7	..	..	..	..	..
13	2	..	..	..	3.5	..	..	..	..	..
13	2	..	..	..	11.5	..	..	..	..	..
13	2	..	..	..	10.5	..	..	..	..	..
13	2	..	..	..	8.8	..	..	..	..	..
13	2	..	..	..	5.9	..	..	..	..	..
13	3	..	..	..	3.0	..	..	..	..	..
13	3	..	..	..	10.7	4.6	..	..	..	..
13	3	..	..	..	..	7.4	2.2	..	..	..
13	3	..	..	..	..	4.9	1.9	..	..	..
14	top	..	..	..	4.7	..	..	..	..	..
14	top	..	..	..	2.4	..	..	..	..	..
14	bottom	..	..	..	2.3	..	..	..	..	..
14	bottom	..	..	..	2.0	..	..	..	..	..
14	bottom	..	..	..	2.2	..	..	..	..	..
14	1	..	..	..	8.9	..	..	..	..	..
14	1	..	..	..	12.0	..	..	..	..	..
14	1	..	..	..	11.8	..	..	..	..	..
14	1	..	..	..	10.7	..	..	..	..	..
14	1	..	..	..	5.3	..	..	..	..	..
14	1	..	..	..	9.4	..	..	..	..	..
14	1	..	..	..	13.8	..	..	..	..	..
14	1	..	..	..	3.2	..	..	..	..	..
14	2	..	..	..	21.2	..	..	..	..	..
14	2	..	..	..	15.1	..	..	..	..	..
14	2	..	..	..	20.3	..	..	..	..	..
14	3	..	..	..	16.5	..	..	..	..	..
14	3	..	..	..	9.1	..	..	..	..	..
14	3	..	..	..	22.2	..	..	..	..	..
14	3	..	..	..	13.2	..	..	..	..	..
14	3	..	..	..	18.6	..	..	..	..	..
14	3	..	2.6	2.2	9.5	..	..	..	1.70	0.33
14	3	..	..	..	9.5	..	..	..	1.53	0.23
14	3	..	..	..	18.5	..	..	..	..	..
15	1	..	1.8	2.0	3.0	30.6	3.9	..	1.67	..
15	1	..	7.1	7.5	1.9	..	..	..	2.98	..
15	1	1.5	2.3	2.1	2.4	21.5	4.1	2.1	1.23	0.14
15	...	7.1	2.5	2.2	..	..	..	..	2.51	0.31
15	...	2.1	6.3	6.5	..	..	..	..	1.29	0.19
15	...	5.2	5.2	5.0	..	..	..	..	1.60	0.22
15	...	14.5	4.2	4.6	..	..	..	..	1.31	0.24
16	...	..	..	..	0.9	1.2	6.5	..	..	..
16	...	..	..	..	0.8	3.3	4.9	..	..	..
16	...	..	12.3	13.0	1.1	..	..	..	0.84	..
16	...	2.0	9.7	9.9	0.8	..	..	..	0.56	0.05
16	...	3.2	12.7	12.2	0.8	..	..	..	0.76	..
16	...	2.5	11.7	11.8	0.8	..	..	..	0.74	0.06
16	...	2.1	6.4	5.4	0.9	..	..	..	0.62	0.2?
16	...	1.4	6.7	7.4	0.9	..	..	..	0.29	0.03
16	...	1.6	8.9	10.0	..	..	..	..	0.39	0.07
18	top	0.7	6.1	6.1	2.6	3.9	2.3	3.0	0.48	0.06
18	bottom	0.6	7.9	8.1	1.4	3.3	2.5	1.2	0.45	0.04
18	bottom	1.7	8.9	9.2	3.8	1.7	1.6	2.2	0.40	0.23
20	top	6.9	5.9	7.0	2.1	3.7	2.0	2.3	0.34	..
20	top	..	8.7	9.4	1.5	4.6	3.6	1.7	0.39	..
20	top	1.3	5.8	6.9	2.9	..	..	..	0.41	0.10
20	bottom	5.9	9.8	12.1	2.7	2.2	2.0	2.9	0.68	..
20	bottom	0.8	10.6	11.4	1.9	2.5	1.9	2.1	0.42	0.05
20	bottom	0.8	7.1	5.5	2.9	..	..	..	0.36	0.05
21	...	5.9	7.0	8.2	3.5	..	..	..	0.59	..
21	...	7.6	6.3	6.9	2.4	..	..	..	0.52	..
22	1	..	11.2	11.6	2.3	3.0	0.1	2.6	0.95	..
22	wet	2.7	8.6	8.4	3.4	..	..	..	0.87	0.11
22	11	2.8	9.0	9.1	3.6	..	..	..	0.81	0.10
22	11	0.4	9.5	9.1	2.9	..	..	..	0.53	0.06
22	11	2.8	9.0	9.1	1.9	..	..	..	0.81	0.10

Table VII. The Data Obtained from the Various Standard Tests Run On Strips of Felt from the Paper Mills (*Continued*)

Mill No.	*Press No.*	*Water passage, min.*	*Water gain, g.*	*Water loss, g.*	*Ash, %*	*Ether extract, %*	*Alcohol extract, %*	*Ash after extraction, %*	*Wet volume per gram of felt, ml.*	*Dry weight per gram of felt, g.*
22	11	1.5	8.0	9.4	2.7	..	..	..	0.38	0.03
22	11	0.6	7.9	9.1	2.9	..	..	..	0.37	0.01
23	Pick-up	1.7	6.3	7.5	2.1	1.7	1.6	2.2	0.98	0.06
24	1	3.2	6.2	5.6	1.6	..	..	..	1.10	0.09
24	2	1.7	3.8	3.8	1.4	..	..	..	0.74	0.17
25	...	3.9	3.2	2.3	2.2	6.3	4.3	2.2	0.86	0.03
26	...	3.1	9.2	9.8	2.4	3.1	2.7	2.5	0.51	0.07
27	...	..	..	..	..	2.6	2.1	..	..	..

not be exactly standardized, but in spite of this, relative comparisons can be made between felt samples. All of these methods are of value for indicating the amount of plugging in used felts.

NATURE AND COMPOSITION OF DEPOSITS

To learn more about the deposits in the wet felts various tests were developed to explore their nature.

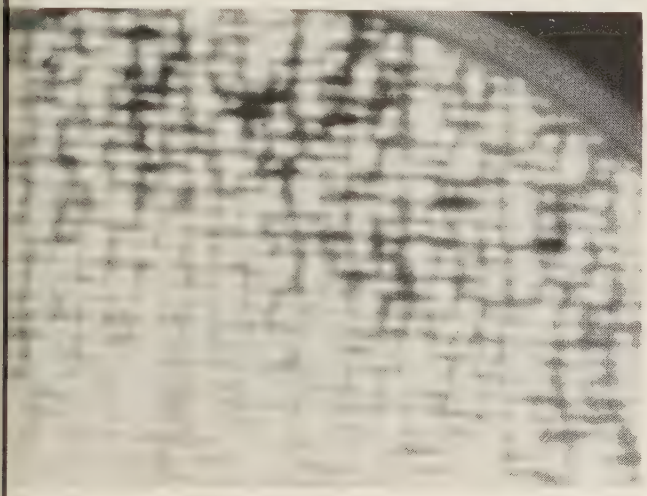


Fig. 11. Section of a used felt from a paper machine using unbleached sulphate pulp

This shows the variation in the amount of plugging. 2×.

It was known that filler material accumulated in the felts and it has been suspected that fine pulp fibers also collected in the felt. It seemed logical to assume that any material, of small size, traveling with the paper sheet might be deposited in the wet felts. This would mean that not only broken wool fibers and wool scales, but also such items as pulp fibers, filler, size, starch, asphalt emulsion, and slime accumulations presumably would be deposited in the felt. To learn the underlying causes of felt plugging it was first necessary to find out what the deposits were, in what quantity they might be present, and what conditions might affect their accumulation in the felt.

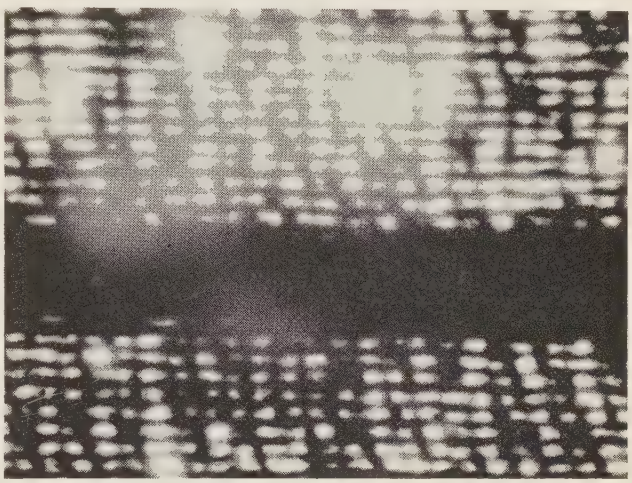


Fig. 12. Section of a used felt from a paper machine using unbleached sulphate pulp. 2×

Deposits such as the diatomaceous earths, can be easily identified, but these are exceptions. The deposits may consist of fragments of wool scales and yet not be recognized as scales; clay particles resemble bacteria, and bacteria resemble clay particles, especially when the bacterial cells are dead. Even wood fibers often are broken into fragments which are not easily identified. The following techniques were developed to study the nature and composition of these deposits.

Table VIII. The Effect of Washing on the Rate of Passage of Water Through Felts[a] (Water Passage)

First wash	*Second wash*	*Time required for 1 liter of water to pass through 314 sq. mm. of felt* *Before washing, sec.*	*After first wash, sec.*	*After second wash, sec.*
Dreft	...	17	17	..
Dreft	...	26	22	..
Dreft	...	30	15	..
Dreft	...	32	16	..
Dreft	Dreft	46	29	29
Dreft	Dreft	60	27	24

[a] These felts had been used in manufacturing bleached sulphate paper.

Table IX. The Effect of Washing on the Water Absorption of a Felt[a]

Wet weight		*Water gain*		*Water loss*	
Before gr.	*After washing, gr.*	*Before, gr.*	*After washing, gr.*	*Before, gr.*	*After washing, gr.*
29.5	39.3	15.5	19.0	15.8	18.0
30.8	42.0	14.3	20.9	14.4	21.7
31.0	41.4	12.6	20.9	14.9	21.9
31.2	..	11.9	..	13.8	..
28.8	..	14.3	..	13.8	..
Av. 30.3	40.9	13.7	20.3	14.5	20.5

[a] Felt from an unbleached sulphate mill.

Ash Test

This test, a common chemical procedure, was adopted as a method of measuring the amount of filler retained by a felt. A recent paper by Koch, Brandon, and Geohegan (*4*) presents information on detecting, qualitatively, filler materials such as clay, titanium dioxide, talc, and diatomaceous earth. For the ash test, approximately 5 grams of each felt sample were burned to an ash. The felts were brought to a constant weight at 70°C. before weighing. Table VII summarizes the data on this test.

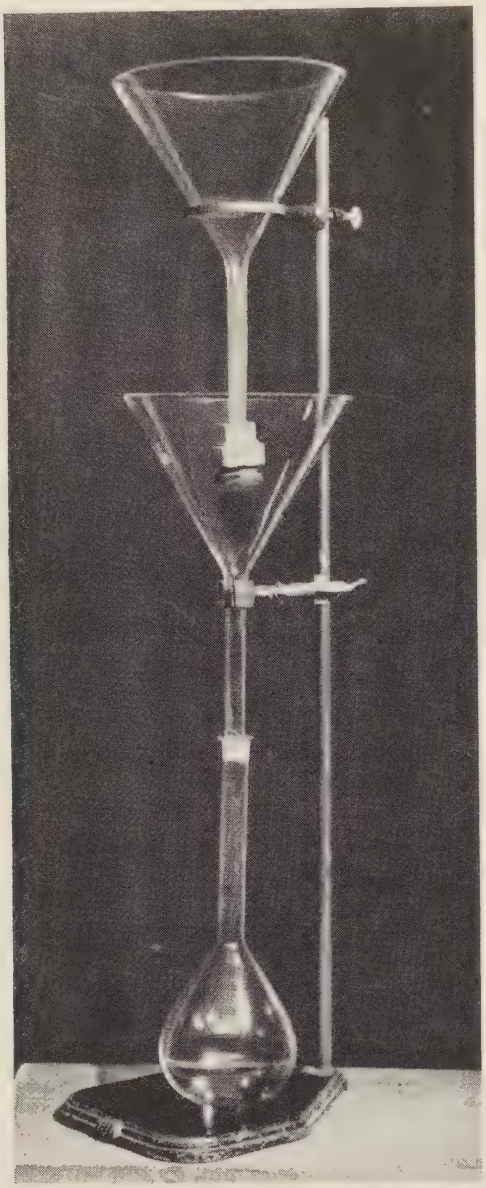


Fig. 13

A new felt had 0.4% ash, rosin size had 9.3% ash, and wood pulp had 0.5% ash. This means that the felt and any small amount of pulp fibers would contribute a negligible amount of ash. The ash must come from filler, size, or special materials such as asphalt emulsion.

In mill no. 13 there was no correlation between the percentage of ash and the amount of filler. In mill no. 14 there was slight correlation between the percentage of ash and the amount of filler for the first, second, and third presses (Fig. 17). One of the third press felts was in operation for 139 days which accounts for the percentage of ash of 22.2, when only 25 lb. of filler per ton of paper was added. There was no correlation between percentage of ash and size or between percentage of ash and a combination of filler and size.

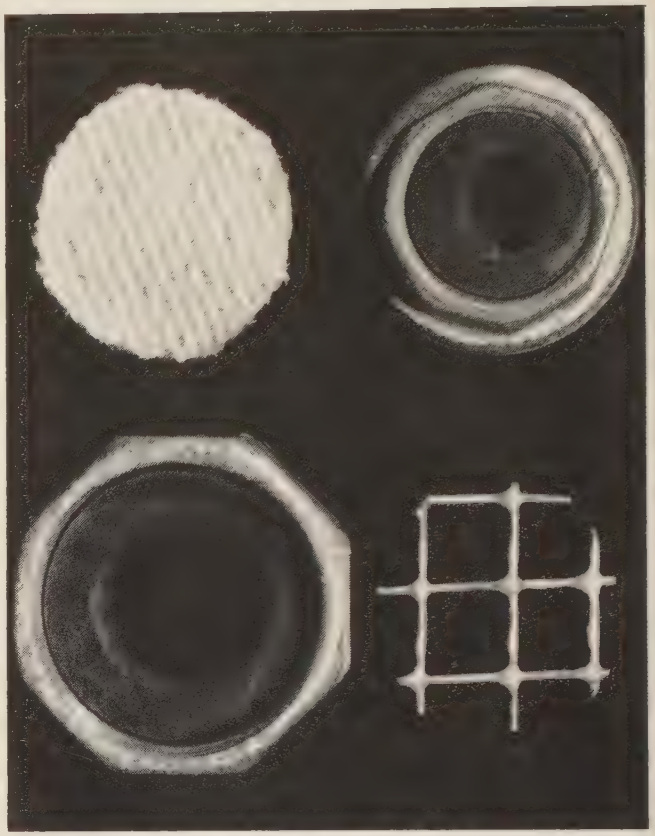


Fig. 14. Close-up of cell arrangement shown in Fig. 13

Top left is felt sample and lower right is supporting wire. The other parts consist of a pipe fitting with rubber inserts.

It was expected that the percentage of ash would increase with the operation time. This did not always hold true. The expected trend occurs in mill no. 14 for the second and third presses. Here there was an increase in per cent ash with increased running time, and it took less time for the felts carrying a sheet with more filler to reach the higher percentage of ash. On the other hand, no such trends were obvious for the first press in mill no. 14 or in any but the third press of mill no. 13.

An interesting comparison concerning the percentage of ash was made in Fig. 18 between the amount of plugging as determined by microscopic examination and the percentage of ash. Apparently the microscopic readings were not so accurate at the higher percentages, which was expected. It was easier to estimate between 30 and 40% than between 80 and 90%.

The ash test was of value in determining the amount of filler present in the felt. The complete lack of correlation between amount of ash and amount of size

Table X. The Per Cent of Deposits Determined by Digesting the Felt with 10% Sodium Hydroxide

Mill No.	Machine No.	Press No.	Weight of deposits: First sample, g.	Weight of deposits: Second sample, g.	Percentage of original weight: First sample, %	Percentage of original weight: Second sample, %	Percentage of original weight: Average, %	Microscopic estimate of plugging, %
		new felt	0.075	0.040	3.8	2.0	2.9	0
13	4	1	0.522	0.608[a]	26.1	30.4	28.3	54
13	1	1	0.165	0.095	8.2	4.8	6.5	16
14	7	2	0.475	0.490	22.8	24.5	23.7	73
14	8	bottom	0.163	0.185	8.2	9.2	8.7	40
14	7	1	0.158	0.180	7.9	9.0	8.5	62
16	..	1	0.250	0.270	12.5	13.5	13.0	70
16	..	2	0.253	0.182	12.6	9.1	10.9	55

[a] Fibers were not completely digested.

uld indicate that sizing materials do not affect plug- by fillers or contribute in themselves, to the per- ige of ash. It must be pointed out, though, that produces one tenth as much ash as filler and may felts as effectively as filler, only with less bulk red.

ther-Alcohol Extractions

ther-alcohol extractions were made to determine at portion of the deposits were pitch and rosin. section of felt approximately 10 grams in weight was into thin strips and brought to a constant weight at °C. After weighing, the sample was placed in a ndard Soxhlet extractor. The samples were ex- cted with ethyl ether for 16 hr. The ethyl ether as removed and the sample dried to a constant weight 70°C. The ether-extracted felt sample was then tracted with 95% ethyl alcohol in the same equip- nt for 16 hr. The ethyl alcohol was removed and the tract dried to a constant weight at 70°C. This pro- dure is basically the same as the TAPPI standard titled "Pitch in Wood Pulp" (*7*). Table VII pre- nts the data obtained from the extractions.

A felt from a newsprint mill, which was troubled th pitch accumulations, had a high percentage of tractives, 13.5%. This felt is shown in Fig. 19.

In mills that add a large amount of size to the pulp, ere is a high percentage of ether-alcohol extractives the felt as shown by the results for mill no. 15 for ich the total extractives were 34.5%. In mill no. 13 e difference in per cent of extractives corresponds to e water passage data for these two samples which re from the same felt. A water passage value of .1 and total extractive of 9.6% was in contrast with water passage value of 1.5 and a total of 6.8% ex- actives. Even though the difference in water pas- ge cannot be easily explained by the small difference extractives, it might point to the possibility that all changes in the amount of extractives are impor- nt. Evidently, the relationship between amount of tractives and water passage is not necessarily linear.

emical-Physical Tests of the Deposits

This section presents the results of a series of tests determine the identity of the deposits. A tremen- us volume of pulp fibers travels over a felt during the e of the felt on the machine. It would be expected at fine pulp fibers and fragments of fibers ould work their way into the felt and comprise a rtion of the deposits.

The amount of cellulosic material in the felt was checked by using chlor-iodide of zinc which imparts a blue color to cellulose material. This indicator was first tested on rosin size, talc, clay, titanium dioxide, and diatomaceous earth. No change in color occurred except that the clay turned to a pinkish tan. The wool fibers, including scales, were not stained. Pulp fibers turned blue throughout, except for a few objects that were not stained. Felt samples from an unbleached sulphate, sulphate-sulphite, and a sulphite-soda mill were tested. Only an insignificant amount of cellulose material was present. When freehand sections of felt samples were tested only an occasional wood fiber was detected. When the deposits, removed by the Waring blendor, were tested, more cellulose material was present but comprised only 0 to 2% of the total plugging material. Apparently clumps of pulp fiber may accumulate and adhere to the surface of a felt, but do not work their way into the felt. In no case did wood fibers contribute a significant proportion of the deposits:

The Liebermann-Storch test (*3*) for pitch and rosin produced positive results. In this test felt samples were crushed with acetic anhydride on a spot plate and then concentrated sulphuric acid was added. The presence and, to some extent, the relative amount of pitch could be detected by a change in color ranging from yellow to red. Tests on a dry size and emulsion size gave a strong positive reaction. Samples of felts from unbleached sulphate, bleached sulphate, sulphate-sulphite, and sulphite-soda mills in addition to a new felt sample were tested. The new felt tested negative,

Table XI. The Water Passage Values and the Percentage of Ash in New Felts Run Through Different Combinations of Materials

Material added to water	Water passage, min.	Amount of ash, %
1. Clay, BSM-11	0.55	2.4
2. Clay	0.51	4.1
3. Same as 1	0.46	2.5
4. Same as 2	0.53	5.8
5. Clay, diatomaceous earth, talc, and BSM-11	0.45	2.9
6. Clay, diatomaceous earth, and talc	0.58	13.1
7. Same as 5	0.49	2.3
8. Same as 6	0.61	8.5
9. Pulp, BSM-11	0.67	1.7
10. Pulp	0.65	1.8
11. Same as 9	0.91	1.3
12. Same as 10	0.88	1.5
13. Rosin, BSM-11	1.24	2.3
14. Rosin	1.03	2.6
15. Same as 13	1.24	2.1
16. Same as 14	1.26	2.2
17. BSM-11	1.14	1.5
18. Nothing	0.79	2.1

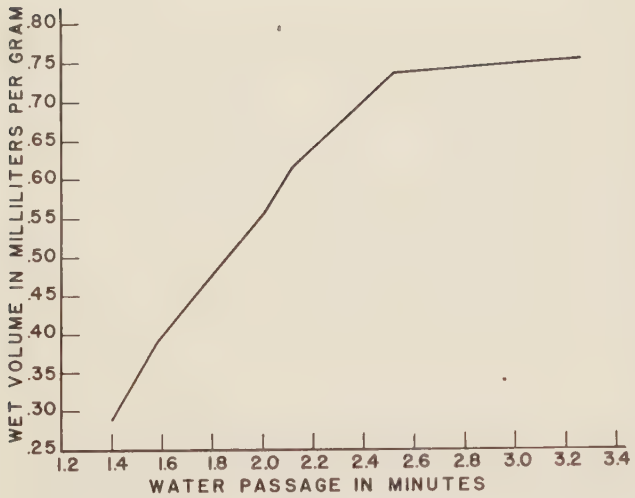


Fig. 15. The effect of wet volume on water passage in a sulphate mill

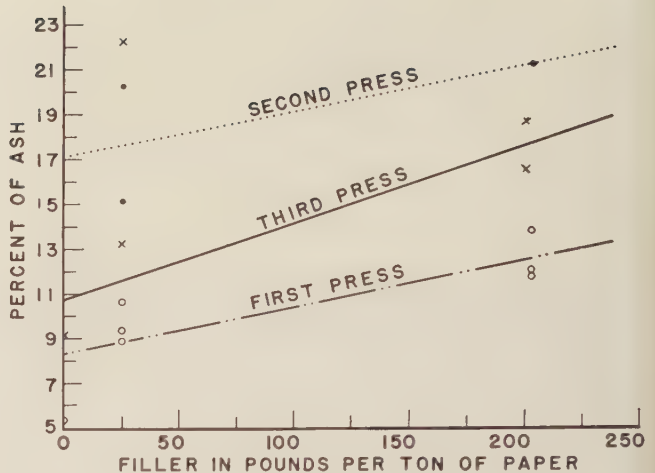


Fig. 17. The effect of the amount of filler on the per cent of ash

the felts from the two sulphite and the bleached sulphate mills gave the strongest indication of rosin and pitch, and the unbleached sulphate mill felt only a faint violet color. This corresponded approximately with the amount of sizing material which had passed over these felts. The sulphate mill felts were on the machine a shorter time and had an average of 4 lb. of size per ton of board. The two sulphite mills had an average of 23 lb. of size per ton of paper. The bleached sulphate felt carried the highest amount of size, 72 lb. per ton of paper.

Deposits that were removed from felts, by means of a Waring blendor, were subjected to the Liebermann-Storch test. Using the same felts that were positive for rosin or pitch, it was found that the Waring blendor action removed most of these materials from the felt. The Liebermann-Storch test was applied to felt samples that had been extracted with the standard ether-alcohol extraction discussed in a previous section. There was very little difference, microscopically, between the extracted and nonextracted felts. The nonextracted felts tested strongly positive for rosin or pitch and the extracted samples were negative. The ether extract was strongly positive and the alcohol extract weakly positive.

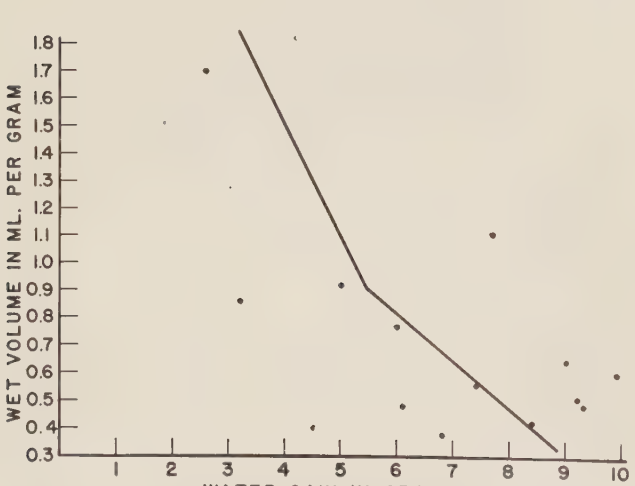


Fig. 16. The effect of wet volume on water gain

Bacterial resins were examined by this same method. Twenty different bacterial isolates were obtained from felts and large quantities of each were tested. Seven of them gave a red reaction, but this reaction was different from that obtained in the previous tests. Those bacteria that did turn red were extracted with ether and alcohol. The extract gave a negative Liebermann-Storch test. It may be concluded from this that resins from sources other than bacteria accounted for positive results in the Liebermann-Storch test.

Tests for the detection of presence of bacteria in felts included the use of 2, 3, 5 triphenyl tetrazolium chloride (T-T-C) (*5*). This material will stain living

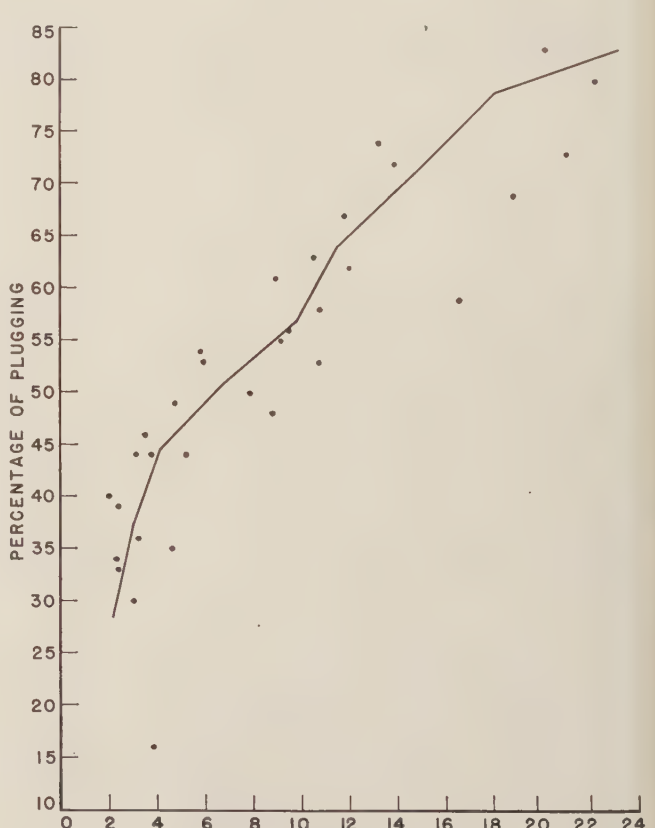


Fig. 18. Percentage of plugging plotted over percentage of ash in two mills using fillers

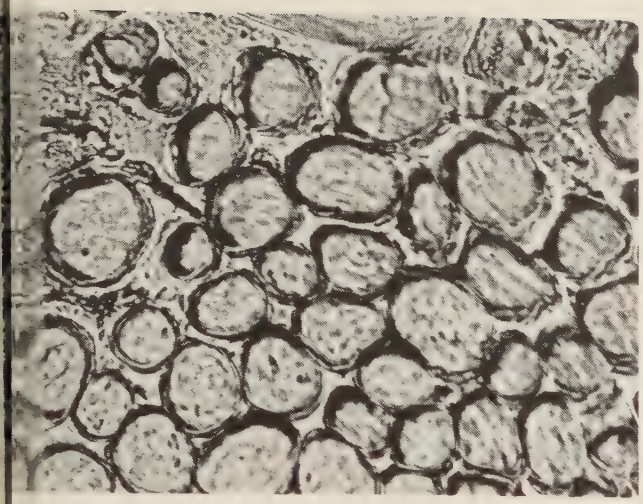


Fig. 19. Section of a used felt from a paper machine making newsprint showing pitch deposits between the felt fibers. 270×

cteria a red color and thus can be used as an indicator r developing colonies. Investigation with T-T-C monstrated that masses of deposits adhering to the ers, or broken up and separated, often showed no ving colonies. This does not preclude the presence masses of dead bacteria but strongly indicates that rge proportions of the deposits were composed of her materials.

Various stains were used that supposedly would segre ate bacterial cells from other material, but none of em was satisfactory.

Solubility tests were used to separate the deposits nd thus obtain further indication of their composition. oncentrated nitric acid turned wool fibers yellow, nd turned scales, removed from a new felt, a purple rown color. This color corresponded to that result- g from the treatment of various fatty acids with tric acid. Deposits from felts used in unbleached lphate mills did not turn yellow, but remained brown.

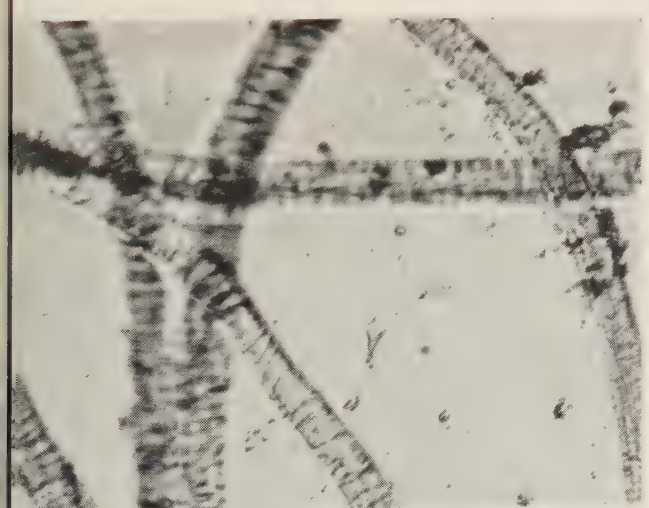


Fig. 20. Section of a new felt subjected to a suspension of bacteria and clay

This shows the development of deposits under laboratory nditions. 175×.

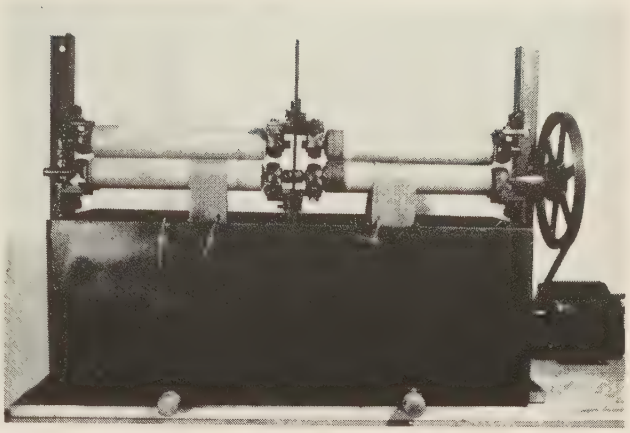


Fig. 21. Automatic equipment for testing felt plugging in the laboratory

Separation of wool fibers and deposits with 10% sodium hydroxide was investigated. Felts from a sulphate mill, sulphate-sulphite mill, and a sulphite-soda mill, in addition to a new felt were tested. Felt samples were ground in a Wiley mill to pass through a 20-mesh screen. Duplicate 2-gram lots were placed in 125-ml. flasks and 25 ml. of sodium hydroxide solution were added. The material was boiled 1 min. and filtered through weighed filter papers. Table X shows the results of wool fiber digestion and separation of deposits. The percentage of total weight of felt sample consisting of deposits, corresponded roughly with the percentage plugging determined by microscopic examination.

It was suspected from microscopic examination of deposits that in some mills a large percentage of the plugging material consisted of wool fiber scales. Millon's reagent, which turns wool fibers to a red color, was used on scales removed mechanically from a new felt. They were not stained nor were the deposits removed from a used felt stained. Examination of these deposits and all tests concerning scales such as nitric acid treatment and staining with Millon's rea-

Fig. 22. Section of a new felt that had run for 7 days on the automatic equipment (Fig. 21)

No bacteria were present. 175×.

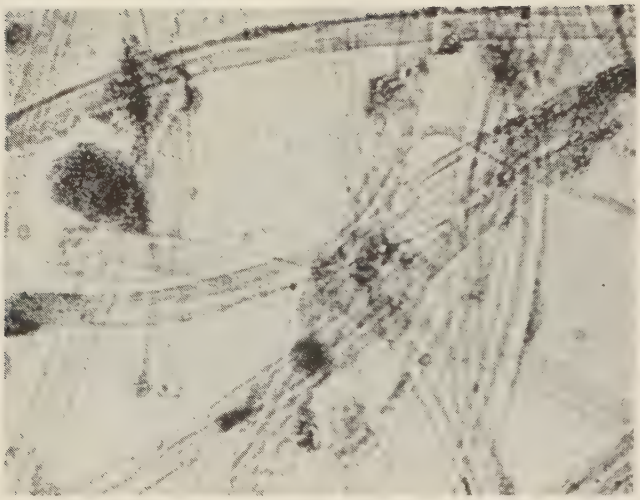


Fig. 23. Section of a new felt that had run for 7 days on the automatic equipment (Fig. 21)

Bacteria were present. 175×.

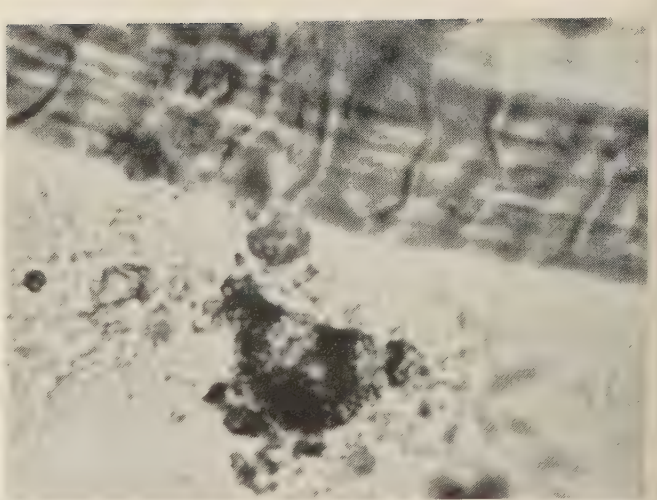


Fig. 25. A close-up of Fig. 24 showing the accumulation of wool scale fragments which resemble deposits in used felts. 750×

gent led to the conclusion that wool fiber scales were an important constituent of plugging.

Dry Weight and Wet Volume Measurements of Deposits in Felts

These were measures of the amount of deposits in a felt. Both dry weight and wet volume of the deposits were determined. It was recognized that they might have been made up of completely different substances and a felt could be equally plugged with a material that had a lower specific gravity. The wet volume determination was based on an American Society for Testing Materials Standard entitled "Water and Sedimentation of Petroleum Products by Means of Centrifuge" (*1*). It was obtained in this way. Three felt samples of approximately 3 grams each were cut into $^1/_4$-in. squares. The samples were allowed to come to equilibrium with the moisture content of the room. Two of these samples were oven-dried for 24 hr. at 105°C. and their moisture content determined on an oven-dry weight basis. The third sample was assumed to have the same average moisture content as the other two samples. The third sample was "blendorized" in 150 ml. of distilled water for 3 min. Contents of the blendor were emptied through a wire mesh funnel (122 mesh to-the-inch) and then the blendor and fibers were gradually washed with 300 ml. of additional distilled water. The fibers were squeezed dry with a stirring rod. The material that passed through the wire mesh funnel was collected in a 500-ml. flask and allowed to settle. Clear liquid was poured off and discarded. It was possible to do this because it was found that only a negligible amount of solids could be obtained from this portion. The balance was centrifuged in a Clay Adams Co. centrifuge at a speed of 4500 r.p.m. and then transferred to 12-ml. tubes and centrifuged in a 220-v. Spencer Lens Co. centrifuge at a speed of 950 r.p.m. until no appreciable decrease in volume was noted. This gave the wet volume of the deposits. This same material dried for 24 hrs. at 105°C. gave the dry weight of the deposits. The results of determinations on wet volume and dry weight of deposits are recorded in Table VII. The wet volume

Fig. 24. Section of a new felt that had been inoculated with bacteria

The deposits consist of bacteria and wool fiber scales. 175×.

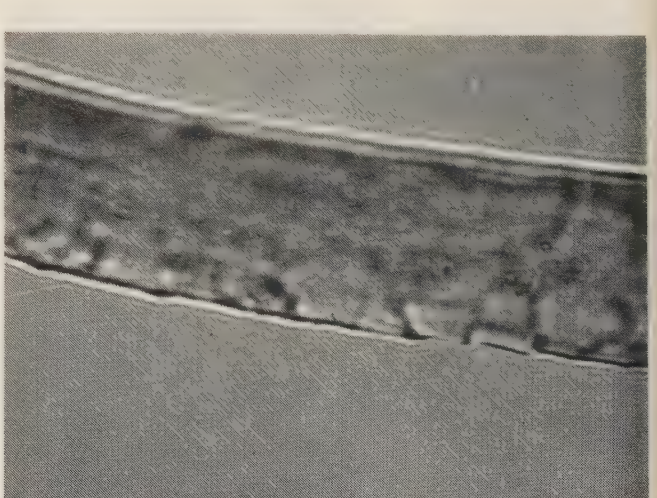
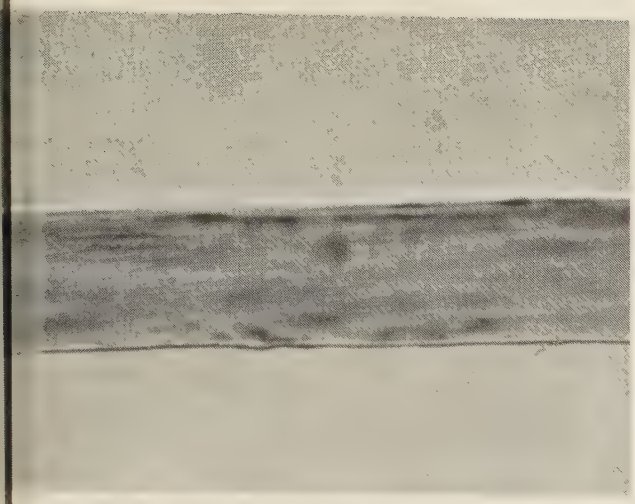


Fig. 26. A wool fiber that was "blendorized" for 1 hr. in water only

The fiber scales are still present and the fiber is in fair condition. 750×.



. 27. A wool fiber that was "blendorized" for 1 hr. in a water suspension of clay

he fiber scales have been removed but the cortical cells are . 750×.

ues were a good measure of the amount of plugging a felt and the deposits obtained by "blendorizing" felt are in a convenient form for further study.

ltures of Deposits from Used Felts

Cultures of deposits were made to find out what por- n of the particles adhering to the fibers were made up living bacteria. Felt samples embedded in methyl thacrylate were cultured and in no instance were cteria found to have survived the embedding proce- re. Hanging drop cultures were made of fibers from ed felts that had deposits adhering to the fibers. If e felt was untreated, bacteria developed in every se. The accumulations adhering to the fibers did t give rise to masses of bacteria, as would be expected iiving bacteria made up much of their bulk. Colo- s of bacteria developed all along the fibers and did t seem to be particularly associated with the deposits.

e of Fluorescent Light

An ultraviolet bulb (Westinghouse 250W) was used

. 28. A wool fiber that was "blendorized" for 1 hr. in a water suspension of bacteria

The fiber scales have been removed and the cortical cells are ng removed. 750×.

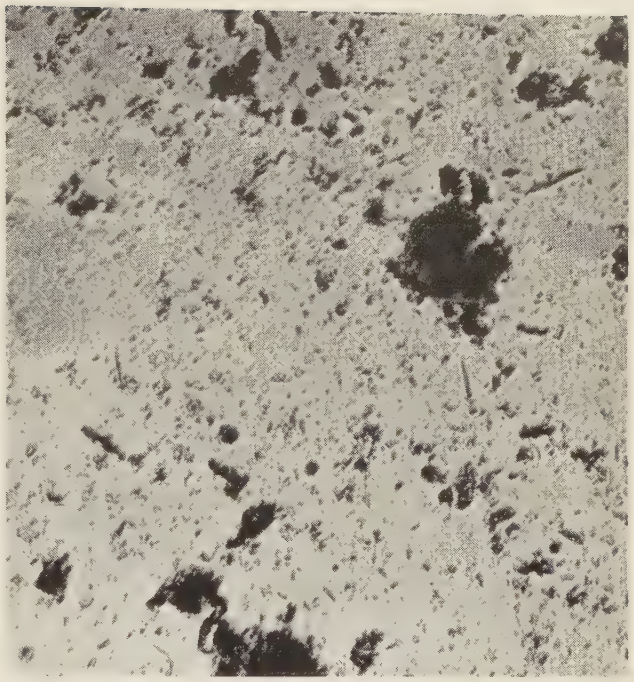


Fig. 29. Deposits removed from a felt on a paper machine processing unbleached sulphate pulp

A few cortical cells are present and the wool scales have formed imbricated mats. 175×.

to examine felts and various materials involved in felts. This method was of no value in detecting the nature of deposits—so many materials fluoresced a red color that no real separation could be made. When a magnification of 450× was used it was impossible to obtain separation of known materials.

EXPERIMENTAL PLUGGING OF FELTS

The objective of the work reported in this section was to determine, on the basis of controlled experiments, what part bacteria played in plugging felts. According to the information presented in the previous section, it was believed that bacteria in themselves did not comprise a large proportion of the plugging material. It was found that the bulk of the deposits were materials that had been added to the felt or were part of the

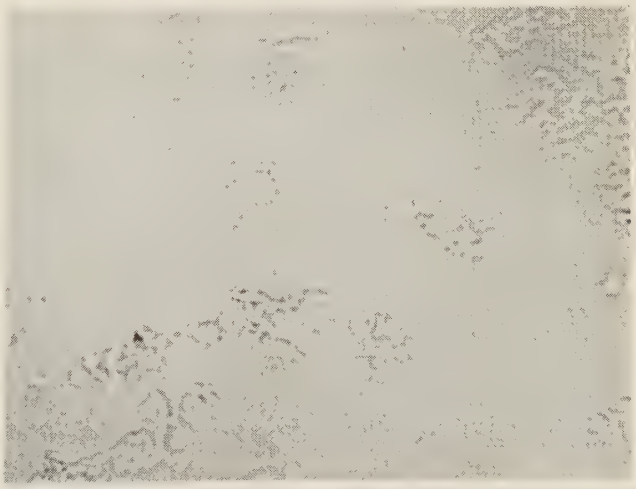


Fig. 30. Wool fiber scales removed from a new felt, showing the typical shapes of these scale fragments. 750×

felt, presumably scales that had been removed from the fibers. On the other hand, it was apparent that some factor, such as bacteria, might be very important as an accelerator for plugging. This implies that bacteria might be capable of forming a nucleus for plugging material and thus entrap and hold fillers and other such material. Secondly, the bacteria may increase the speed with which wool scales are removed from the fibers and collected in the area between fibers. Mechanical action, of course, accounts for the removal of wool fiber scales and chemical action also can affect the removal of scales, if conditions are favorable (*6*).

Preliminary tests with new felts showed that the presence of bacteria would result in increased plugging. This was substantiated by the following test. Pint jars were made up with the following combinations of materials: (1) clay and water; (2) clay, titanium dioxide, diatomaceous earth, talc, and water; (3) pulp and water; (4) rosin and water; and (5) water. Four jars were made up for each of the five combinations and

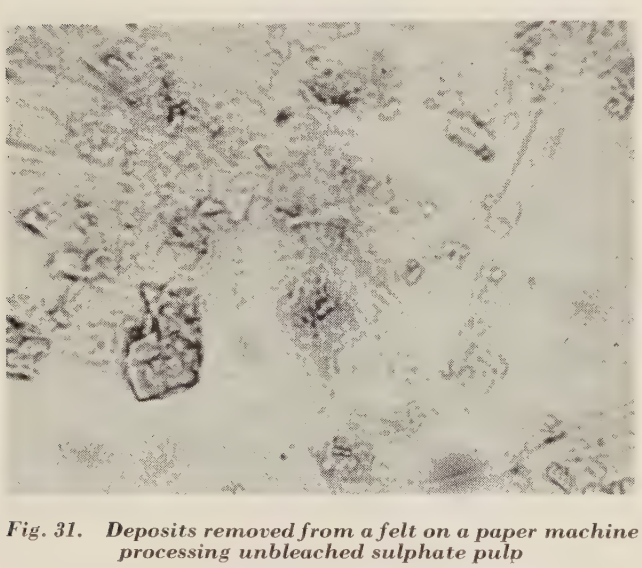


Fig. 31. Deposits removed from a felt on a paper machine processing unbleached sulphate pulp

This felt had a short life because of excessive bacterial activity. The deposits were largely wool scale fragments and cortical cells. 750×.

a bactericide was added to half of the jars. The pH was adjusted to 6. New felt samples 5 by 10 cm. were submerged in a water suspension of bacterial inoculum. They were then placed in their respective jars and the contents of each jar stirred. The felts were removed and run through a hand wringer. This cycle was repeated once each morning and once each evening for 24 days. Deposits were present in the felt samples and closely resembled deposits in felts received from paper mills (Fig. 20).

A quantitative check on the relative amount of plugging in treated and untreated samples was run, using the water passage and ash tests. The results are in Table XI.

Assuming that the preservative had no other effect than to prohibit bacterial development, the bacteria were responsible for holding filler material in the felt. This resulted in slower rates of water movement through the felt and a higher percentage of ash.

The same general test was run using equipment for automatic dipping and wringing of felt samples (Fig. 21). The $^1/_3$-hp. motor, operating a common shaft for both tanks, drove the felts at the rate of 200 f.p.m. To keep the motor from overheating, a timer was inserted which allowed the machine to run and stand idle alternately for 15-min. periods. Samples were removed periodically to determine the relative changes that might have occurred. Preliminary runs were made with a new felt. A water suspension of clay was added to both tanks. BSM-11† was added to one of the two tanks to prevent bacterial activity. Examination at the end of one week of running time showed that more plugging occurred in the tank which did not contain the bactericide (Figs. 22 and 23).

In conjunction with these tests, other new felt samples were submerged in water suspensions of bacteria. In a few days deposits were forming which consisted of living, active bacteria. In addition there were some accumulations in which no bacteria were apparent and which were probably aggregates of fiber scales (Figs. 24 and 25). Subsequently the fibers were completely deteriorated by the bacteria.

It has been a general mill experience that felts removed from paper machines, allowed to stand, and then replaced on the machine will not perform satisfactorily and apparently are more plugged than when removed. If this is due to bacterial activity, treatment of the felt with a bactericide should enable the felt to maintain its absorbent properties. To investigate this subject, treated and untreated felts were tested for their water absorption properties. At a sulphate-sulphite mill, a felt was removed from the machine, cut in half, one half treated with Busan and the other half left untreated. Eleven days later the treated sample absorbed 5.3 grams of water and the untreated felt, 4.2 grams of water. The same samples were maintained in a moist condition for 9 days in pint jars. The treated sample was subjected to formaldehyde vapors. This time the treated sample absorbed 4.1 grams of water and the untreated 3.6 grams. The water absorption values had decreased in relation to the original test.

Another treated and untreated felt from a sulphate-sulphite mill was tested for water absorption. In this instance the treated felt had been soaked in a solution containing phenyl mercuric acetate. The treated felt absorbed 4.39 grams of water and the untreated sample 2.80 grams. These samples were submerged in water for four days and retested. The water absorbed by the treated felt was 5.39 grams and for the untreated sample 4.10 grams. It is apparent that a change takes place in felts when they are removed from the machine which can be restricted by adding a bactericide.

The evidence of this investigation indicated that fragments of wool scales are an important constituent in plugged felts. It was thought possible that bacteria might accelerate the removal of the scales from the fibers. This was checked by Waring "blendorizing" new felts in water, in a water suspension of clay and in a bacterial water suspension. BSM-11 was

† BSM-11, a product of Buckman Laboratories Inc., is a combination of 10% phenylmercuric acetate, 50% potassium 2,4,6 trichlorophenate, and 40% inert ingredients.

ded to the first two treatments to prevent bacterial tivity. After a 1-hr. run in the Waring blendor the ers from each of the three treatments could be separated on the basis of the extent of damage to the ers. The fibers that were run in the blendor with eria were deteriorated more than either of the her sets. The fibers subjected to the blendor with y and water were intermediate in condition of the ers (Figs. 26, 27, and 28).

The material removed from a new felt by a Waring dor, when no extraneous material is present, reples bacterial cells but on microscopic examination X) these particles turn out to be fragmented wool les. These particles can be positively identified use of their angular, often triangular shape, and gular outline. This statement is based on microic observation of material known to be scales and ir distinctive appearance when compared with pertinent material. This material has a strong ity for itself and the individual particles would form ts of material resembling deposits in used felts gs. 29, 30, and 31). A large percentage of material oved from a new felt by "blendorizing" is colloidal nature. Cortical cells were present in the liquid terial at the end of 40 min. in the blendor. These sults indicated the importance of fragmented wool les as a major constituent of plugging and as a frameork for holding other material. The results also inated that bacteria contribute significantly to the sening of scales from wool fibers in addition to the ect of bacteria in entrapping wool scales and other rticles, particularly filler particles.

SUMMARY AND CONCLUSIONS

1. Paper machine felts may be plugged to the ext that 90% of the space between the fibers is filled th extraneous material which interferes with proper nctioning of the felt.

2. There are several ways in which the amount of gging can be determined. These are:

(a) Microscopic examination of embedded sections th visual estimates of the percentage of interfiber ace occupied by deposits.

(b) Water passage—rate at which water will pass ough a felt.

(c) Water absorption—the gain in weight of a felt en submerged in water and the subsequent loss in ight when passed through a wringer.

(d) Wet volume of deposits—the volume of desits removed from a felt by dispersion with a Waring ndor and subsequent consolidation of the deposits centrifuging.

(e) Dry weight of deposits—the oven-dry weight of deposits removed by the Waring blendor.

3. Microscopic examination of sectioned felts proed indication of the following:

(a) Plugging is more of a problem in first press s and progressively less in second and third press s.

(b) To a limited extent, felt washing decreased the ount of plugging found in the felt upon removal from paper machine.

(c) The amount of filler and size could not be conently linked with an increased or decreased amount plugging.

4. The amount of plugging as determined by the various methods could be correlated, one method substantiating another.

5. The following tests were tried in determining the materials present in felts:

(a) The ash test—indicated presence of fillers and was an excellent measure of plugging for those felts in which the deposits were predominantly filler.

(b) Ethyl ether—ethyl alcohol extractions demonstrated that pitch or rosin size did not comprise a large proportion of the deposits in the felts from most mills. It is possible that pitch or rosin size may be important in holding other material and that smaller quantities may more effectively plug felts than is true for filler. It also is recognized that under some conditions pitch or rosin size may constitute the major portion of the deposits.

(c) The chlor-iodide of zinc test provided evidence that pulp fibers are present and may be abundant on the surface of the felts. Very few cellulose fibers were found within the felt threads.

(d) Such methods as Liebermann-Storch, use of 2, 3, 5 triphenyl tetrazolium chloride, ultraviolet light, and partition chromatography were essentially of no value in separating bacteria from the balance of the deposits found in felts.

6. Wool scale fragments constituted a major portion of the deposits in the felts from several mills, and in particular sulphate mills. This material may resemble bacterial cells and may be more abundant because of bacteria. Wool scales can be detected, in general, by treatment with nitric acid. These scale fragments had a tenacious affinity for each other and would form into aggregations that on drying would produce a sheet of deposits.

7. New felts inoculated with bacteria would retain two to four times as much filler material as was retained by felts in which bacterial action was prohibited. Waring blendor action caused greater breakdown of fibers when bacteria or clay was present, the bacteria being more effective than the clay in promoting this deterioration.

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Received Jan. 31, 1952. Presented at the 37th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 18–21, 1952.

Paper No. 2796, Scientific Journal Series Article, Minnesota Agricultural Experiment Station, University Farm, St. Paul, Minn. This is a summary of a thesis presented at the University of Minnesota in partial fulfillment of the requirement for the degree of Doctor of Philosophy.

This work was supported in part by a grant from Buckman Laboratories, Inc., Memphis, Tenn., to the Agricultural Experiment Station, University of Minnesota.

The writer wishes to express his indebtedness to Clyde M. Christensen, Division of Plant Pathology and Botany, University of Minnesota, and Stanley J. Buckman, Buckman Laboratories, Inc., for invaluable suggestions and aid during the course of this study.

The Stiffness of Paper

NBS Stiffness Tester

F. T. CARSON and VERNON WORTHINGTON

An instrument to determine the stiffness of paper is described. The specimen is bent through a given angle, and the bending moment is measured as the torque in two lengths of piano wire between which the clamp that holds the specimen is suspended. Stiffness of paper is conveniently defined as the bending moment per unit width of specimen producing unit curvature at the torque axis. When the equation for a cantilever beam loaded at the end is used to derive an expression for stiffness as thus defined, in terms of quantities measurable with the stiffness tester, the expression becomes $(ML/3b)f(\theta)$, in which M is the bending moment, L and b are the length and width of the specimen, θ is the bending angle, and $f(\theta)$ represents certain prescribed expressions. This quantity was evaluated for eight types of paper, for various lengths and widths of the specimen, and for bending angles from 5 to 30°. The stiffness value for a given specimen remained substantially constant when the width and bending angle were varied, but increased somewhat as the bending length of the specimen was increased. A more nearly constant value was obtained when L in the above expression for stiffness was replaced by L^n, where n is approximately 0.8 and $f(\theta)$ is the reciprocal of the angle or of its tangent.

VARIOUS methods and many devices have been proposed for the measurement of the stiffness of paper, textiles, and highly flexible materials, and stiffness has been defined in various ways. Most available paper stiffness testers measure stiffness in an arbitrary and relative manner, evaluating such quantities as the force required to bend a strip of paper through a certain angle, or to deflect the end a given amount. Some determine the length on which a given force must act to produce a given effect. Stiffness of paper is therefore usually defined implicitly as some force, moment, angle, or length that will produce a given effect on a specimen of given dimensions strained in a specified manner. A review of various types of stiffness testers especially designed for paper testing is contained in an article by Clark (*1*).

Stiffness is sometimes defined according to the function the strained member is expected to perform. In engineering mechanics the stiffness of a beam is measured by the load that it can carry with a given deflection. In this sense the stiffness depends on how the beam is supported and how it is loaded. On the other hand, various flexural properties may be specifically defined so as to be more or less independent of dimensions and conditions imposed on the stressed member.

In the field of textiles Peirce (*2*) has discussed in some detail the problems and theoretical difficulties of formulating the stiffness and related properties of fabrics. He measured the stiffness of textile fabrics by suspending specimens as cantilevers bending under their own weight and expressed the results as: (1) an effective bending length, equal to the length of the specimen multiplied by a somewhat complex function of the bending angle; (2) a quantity called *flexural rigidity*, defined as the bending moment for unit curvature per unit width of the material; and (3) *bending modulus*, or intrinsic stiffness of the material, proportional to "flexural rigidity" and inversely proportional to the cube of the thickness.

Schiefer (*3*), with his Flexometer, evaluated flexural work, a property closely related to stiffness, and also other flexural properties of textile fabrics. By means of calibrated springs a measure was obtained of the torque necessary to fold the specimen back on itself until a certain minimum angle of fold (angle between the tangents at the two ends of the specimen) was attained, the minimum angle being proportional to the thickness of the material tested. The flexural work was then evaluated from the torque and angle readings. Measurements were also made on paper.

The Institute of Paper Chemistry (*4*) in a discussion preliminary to the study of certain commercial paper stiffness testers, defined some flexural properties related to stiffness. *Flexural rigidity* was defined as the bending moment required to produce unit curvature of bend, and *rigidity* was defined as the "flexural rigidity" per unit width, or the bending moment per unit width required to produce unit curvature of bend.

Clark (*1*), in formulating expressions for data obtained with his apparatus, in which the specimen is disposed as a cantilever bending under its own weight through large angles, defined stiffness as the cube of the critical length multiplied by an arbitrary constant. It appears to be proportional to the modulus of elasticity and the moment of inertia, and inversely proportional to the weight per unit area (*4*).

Sharman (*5*) measured the stiffness of paper with a pendulum damped by a flexing paper ring, and defined stiffness as the bending moment per unit width that produces unit curvature. He pointed out, however, that the modulus of elasticity has different values in various directions in the sheet of paper, and that it is necessary to evaluate a stiffness for machine direction, and a stiffness for cross direction.

Abbott (*6*) measured the stiffness of fabrics, which had been rated subjectively by experts, by means of several methods and found that measurements made with an apparatus similar to that of Peirce (*2*) and expressed as "flexural rigidity," agreed best with the subjective ranking.

Hebeler and co-workers (*7*) devised a "flexometer" with which a torque was applied to a cantilever specimen by means of a rotating clamp, and the reaction force was measured by means of a sensitive elec-

F. T. CARSON and VERNON WORTHINGTON, National Bureau of Standards, Washington, D. C.

ic strain gage. Stiffness was expressed as the elastic dulus ("bending modulus") calculated by means the conventional equation for a cantilever beam d at the end.

THE TESTING INSTRUMENT

The principle of the apparatus described herein was ined some years ago by the authors (*8*) in connec- with an attempt to use stiffness as a measure of ficial wear of currency paper as a result of repeated pling. A test was required that would reflect the nuous deterioration of the paper resulting from the pling treatment. However, tests made with a , but adequately sensitive, model showed that the ess did not decrease continuously, but actually in- ed during the early crumpling treatment, because e corrugating effect that increased the effective ness and the moment of inertia in bending. This or the evaluation of the stiffness of paper, not being

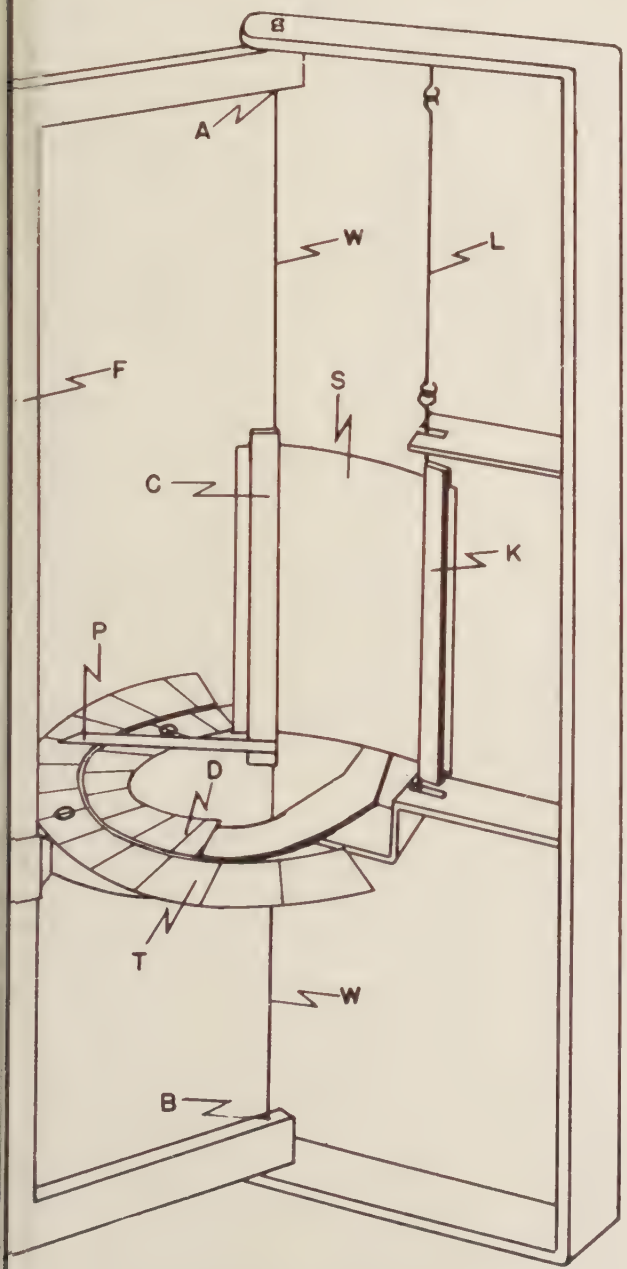

Fig. 1. Schematic drawing to illustrate the principle of the torsion stiffness tester

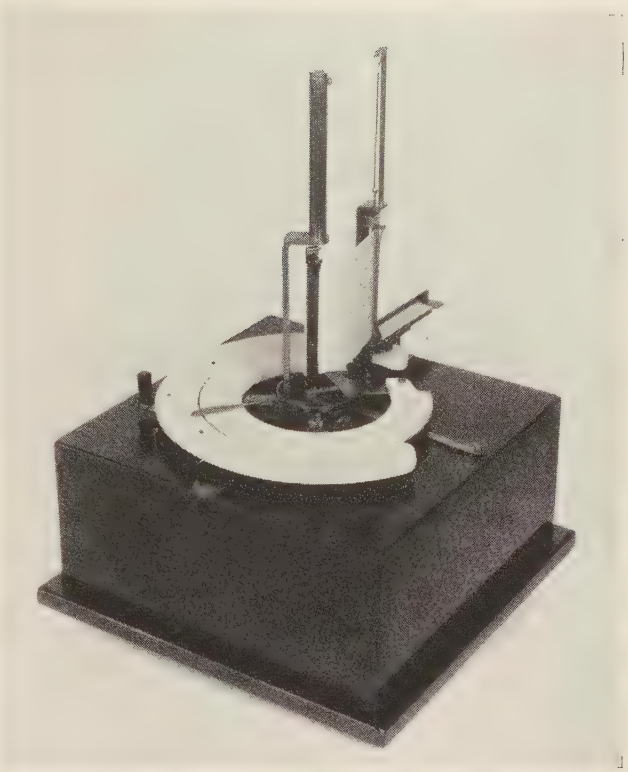

Fig. 2. Photograph of the torsion stiffness tester

applicable to the problem, was laid aside for a time, but more recently was reviewed and further developed.

Figure 1 is a schematic drawing intended to illustrate the principle of operation, Fig. 2 is a photograph of the finished apparatus, and Fig. 3 shows the bent specimen in relation to the clamps. A clamp, C, is suspended between two lengths of piano wire, W (about $^1/_3$ mm. in diameter), the outer ends of the wires being fixed at points A and B to a pivoted frame, F. The wires are fastened to the clamp in line with the clamping edge. One end of the paper specimen, S, is fastened in the torque clamp, C, while the other end is held by a similar clamp, K. In operation, a bending torque is transmitted through the clamp, C, while clamp, K, applies the reaction. The latter clamp is also mounted with its axis through the front edge. This axis corresponds to the free end of a cantilever and must be perfectly free to turn, or to move in the plane of the two axes, so as to allow the specimen to bend freely and naturally, being restrained only from displacement about the axis W-W. The pivots of clamp, K, can move freely in slots in the supporting bracket, while a link L supports the clamp.

The torque is applied by rotating the frame F to which the outer ends of the piano wires are attached. The torque, transmitted through the clamp C, bends the paper through an angle θ (Fig. 3), shown by the position of the pointer P, which is integral with clamp C, on the fixed scale, D (Fig. 1). Simultaneously, the torque is measured by the position of the pointer on the torque scale, T, attached to the pivoted frame, F, that is by the angular displacement of the clamp C with respect to the torque frame, F.

The apparatus owes its sensitivity in considerable degree to the design that eliminates the need of bearings in the torque measuring device. Furthermore, since the

bending axis is vertical, the measurement is uncomplicated by a gravity component.

To increase the range and usefulness of the instrument, a means is provided for varying the length of the specimen, that is, of changing the distance between the two clamps. The bracket that supports the reaction clamp, K, can be moved along the horizontal scale to the rear (Fig. 2) and clamped in any position. This adjustment allows the effective length to be varied from 2 to 12 cm. This detail is not shown in Fig. 1. The width of the specimen can also be varied. The maximum width that can be accommodated is about 7 cm. Another obvious means of broadening the range of the instrument is to change the diameter and length of the piano wires.

Another detail not shown in Fig. 1 is a means of making the zero adjustment. Paper is seldom perfectly flat, but usually has a little curl. As a result the pointer will usually not register zero on both scales after the specimen has been clamped in place. One should set the zero of the torque scale under the pointer, then move the "fixed" scale, D (by means of the lever at the right in Fig. 2) until the two zeros and the pointer coincide.

To make the test the torque is applied by rotating the frame, F, and the torque scale, T, attached to it. The paper is bent, first to the right and then to the left, to a selected angle of deflection shown on the fixed scale, D, and in each case the corresponding angle on the torque scale is read. The average of the two torque readings is taken as the angular measure of the torque corresponding to the selected bending angle, or angle of deflection.

This operation should be done unhurriedly, yet without needless delay. The readings obtained are time-sensitive, but the paper will ordinarily not show appreciable plastic deformation until it has been held for several seconds in the bent state. A further precaution against error due to plastic strain is to take two readings after bending the paper in opposite directions, and average the two. The average of the two torque-angle readings is converted to a bending moment, in gram-centimeters, by means of a calibration constant, which was determined in the following manner.

The instrument was rotated around the horizontal zero line of the torque scale through 90° until the wires were horizontal. The pointer was then counterbalanced with paper held in clamp C until it returned to zero. A small weight (0.1582 gram) was fastened on the pointer at a known distance from the piano-wire axis. This, of course, caused the pointer to move downward. The instrument was then rotated around the piano-wire axis until the pointer was again horizontal. The moment increment (0.1582 × lever arm in centimeters) divided by the angle read opposite the pointer on the torque scale gave the bending moment in gram-centimeters per degree of torque. This procedure was repeated with different added weights and lever arms, and on both sides of zero on the scale to represent the range of readings usually encountered. The average of these determinations was 0.092 g.-cm. per degree.

The torque angle read on scale T, multiplied by 0.092 gives the bending moment in gram-centimeters for a specimen of a chosen width and length (distance in centimeters between clamps) and for the angle θ (read on scale D) through which the specimen is bent. The

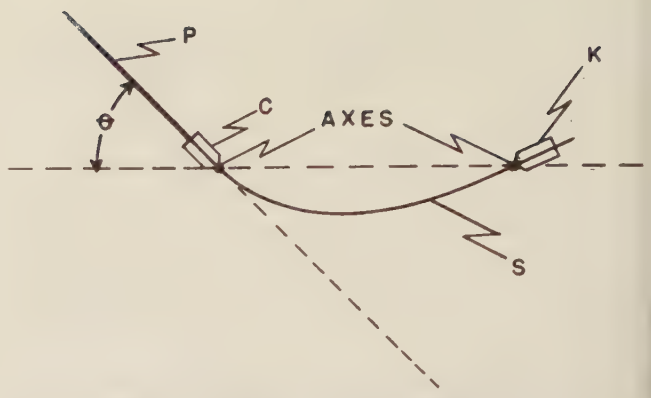

Fig. 3. Diagram showing the bent specimen held at each end in a rotatable clamp, the torque and reaction axes, and the bending angle, θ

bending angle, θ, is the angle between the chord through the two axes and the tangent at the torque axis (Fig. 3).

DEFINITION OF STIFFNESS OF PAPER

In the study here reported the stiffness of paper has been defined as the bending moment per unit width of the specimen and per unit curvature of the specimen at the torque axis. Stiffness thus defined is the same as the "flexural rigidity" of Peirce and Abbott, the "rigidity" of the Institute of Paper Chemistry, and the "stiffness" of Sharman.

The following equation expresses in symbols the stiffness of paper as defined above, and shows how it is theoretically related to the other quantities in the equation for the elastic deflection of a cantilever beam loaded at the free end:

$$S = \frac{M}{Kb} = \frac{MR}{b} = \frac{EI}{b} = \frac{Ed^3}{12} = \frac{ML^2}{3bF} = \frac{ML}{3b} f(\theta) \quad (1)$$

since $MR = EI = ML^2/3F$ for the case assumed when θ is small, $I = bd^3/12$ for a rectangular cross section, and $f(\theta) = L/F = 1/\sin\theta = 1/\tan\theta = 1/\theta$ (when θ is small).

In equation (1) S is the stiffness, M is the bending moment at the torque axis, b is the width of the specimen, $K = 1/R$ is the curvature, R is the radius of curvature at the point on the elastic curve where the moment is applied, that is, at the torque axis, E is the elastic modulus (bending modulus), I is the moment of inertia, d is the thickness of the specimen, L is the span or bending length (distance between the axes of the two clamps), F is the deflection of the free (loaded) end (corresponding in Fig. 3 to the distance from the chord to the end of the tangent that represents the length of the unbent specimen), and θ is the bending angle.

The width, b, and the bending length, L, of the specimen can be chosen at will within the limits of the apparatus, and the bending moment, M, is obtained from the reading on scale T (and the calibration constant) for a chosen value of angle θ on scale D.

There are three principal reasons for choosing the above definition for the stiffness of paper, all of which are linked with the equation for the elastic deflection of cantilever beams, inasmuch as the specimen bent by means of the apparatus pictured in Fig. 2 appears to behave as a cantilever loaded at the free end, when the "wall" is rotated while the "free" end is loaded by the reaction of the "fixed" clamp, K. These reasons are as follows:

Table I. Various Expressions Suggested for $f(\theta)$ in Equation (1) and Their Values for Various Angles

deg.	Values of f(θ)					
	$f_1(\theta)$	$f_2(\theta)$	$f_3(\theta)$	$f_4(\theta)$	$f_5(\theta)$	$f_6(\theta)$
	$\frac{1}{\sin\theta}$	$\frac{\cos\theta}{(3-\cos^2\theta)/2\sin\theta}$	$\frac{1}{\theta}$	$\frac{1}{\tan\theta}$	$\frac{\cos^2\theta}{(3-\cos\theta)/2\sin\theta}$	$\frac{\cos 0.93\theta}{\tan\theta}$
	11.47	11.46	11.46	11.43	11.41	11.39
10	5.76	5.75	5.73	5.67	5.63	5.60
1[illegible]	3.86	3.85	3.82	3.73	3.66	3.62
2[illegible]	2.93	2.91	2.86	2.75	2.66	2.60
2[illegible]	2.37	2.33	2.29	2.15	2.04	1.97
3[illegible]	2.00	1.95	1.91	1.73	1.60	1.53
4[illegible]	1.56	1.44	1.43	1.19	1.02	0.95
5[illegible]	1.31	1.09	1.15	0.84	0.64	0.58

It is desirable to express stiffness in such a way [illegible] it will be independent of the width and bending [illegible]h of the specimen and the angle of deflection. The [illegible] lever equation suggests that this relation should [illegible]ld (within certain limits) for stiffness as defined above.

The stiffness of paper should be so defined as to [illegible]ognize that the fixed thickness is an inherent factor [illegible]he stiffness. A paper, once it has been fabricated, [illegible]s a fixed thickness that is as much a characteristic of [illegible]as its composition or structure. Equation (1) sug[illegible]sts that the stiffness of paper as defined is a function [illegible]the elastic modulus and the thickness.*

Stiffness as defined can be simply expressed in [illegible]ms of the measurable quantities yielded by the [illegible]paratus pictured in Fig. 2, and given in the last ex[illegible]ession in equation (1).

The remainder of this paper is devoted primarily to [illegible]amining the validity of the proposition that the [illegible]ffness of a given specimen of paper, as defined above, [illegible]mains constant as the bending length, width, and [illegible]nding angle are varied, with some consideration of [illegible]odifications necessary to give a constant value where [illegible]e simple relation fails.

STIFFNESS WITH VARIABLE BENDING ANGLE

In the last expression in equation (1), which has been [illegible]osen to evaluate the stiffness of paper, we should ex[illegible]ct the torque or bending moment to be proportional [illegible] the angle θ (or its sine or tangent) only when θ is [illegible]all. It is not feasible to measure accurately very [illegible]all angles with the apparatus described. Further[illegible]ore, paper is frequently bent through rather large [illegible]gles in its many uses, and it is desirable to know [illegible]mething about how the stiffness is affected at these [illegible]rge bending angles. Others have realized the diffi[illegible]lty involved in using the simple expression to evalu[illegible]e data obtained at large bending angles, and have [illegible]empted to modify the cantilever equation, largely [illegible] empirical means, to make it more useful for the [illegible]rger bending angles. At least six expressions for $f(\theta)$ [illegible]ve been suggested. These are given in Table I, [illegible] well as their values for angles from 5 to 50°.

The expression for $f(\theta)$ heading the last column in [illegible]ble I is due to Peirce (*2*), and the simpler forms, of [illegible]urse, follow from the assumption that θ is small. The [illegible]pression for $f_2(\theta)$ was taken from notes on a Danish [illegible]nuscript that came to the authors' attention some [illegible]ars ago, which apparently was not published. It [illegible]ffers little from $f_1(\theta)$ for the range of angles used in the study reported in this paper. Somewhat similar to it, $f_5(\theta)$ can be derived by setting the coordinates x and y for large deflections equal to $L\cos\theta$ and $L\sin\theta$, respectively, and putting these values in place of x and y in the solution of the differential equation for the radius of curvature of the elastic curve.

In the investigation described herein the bending angle was restricted to the range 5 to 30°. Table II shows, for a sulphite bond paper, the stiffness S_1, S_3, S_4, S_5, and S_6, corresponding to the various expressions for $f(\theta)$ in Table I, calculated by equation (1). S_2 was omitted because it differs so little from S_3. Each

Table II. Stiffness of a Sulphite Bond Paper, Machine Direction, Calculated by Means of Equation (1) and the Functions of the Bending Angle, θ, Shown in Table I

$S_1 = k/\sin\theta$, $S_3 = k/\theta$, etc., in which $k = ML/3b$

L, cm.	θ, deg.	k, g.-cm.	S_1, g.-cm.	S_3, g.-cm.	S_4, g.-cm.	S_5, g.-cm.	S_6, g.-cm.
1.5	5	0.28	3.21	3.21	3.20	3.20	3.19
	10	0.58	3.34	3.32	3.29	3.27	3.25
	15	0.88	3.40	3.36	3.28	3.22	3.19
	20	1.18	3.46	3.37	3.24	3.14	3.07
	25	1.45	3.44	3.32	3.12	2.96	2.86
	30	1.68	3.36	3.21	2.91	2.69	2.57
Av. S			3.37	3.30	3.17	3.08	3.02
Av. dev., %			1.9	1.8*	2.0	5.5	6.8
2	5	0.31	3.56	3.56	3.54	3.54	3.53
	10	0.63	3.63	3.61	3.57	3.55	3.53
	15	0.95	3.67	3.63	3.54	3.48	3.44
	20	1.28	3.75	3.66	3.52	3.40	3.33
	25	1.61	3.82	3.69	3.46	3.28	3.17
	30	1.90	3.80	3.61	3.29	3.04	2.91
Av. S			3.71	3.63	3.49	3.37	3.32
Av. dev., %			2.3	0.9*	2.1	4.4	5.6
3	5	0.32	3.67	3.67	3.66	3.65	3.65
	10	0.65	3.74	3.72	3.68	3.66	3.64
	15	0.99	3.82	3.78	3.69	3.62	3.58
	20	1.34	3.93	3.83	3.68	3.56	3.48
	25	1.69	4.01	3.87	3.63	3.45	3.33
	30	2.01	4.02	3.84	3.48	3.22	3.08
Av. S			3.87	3.82	3.64	3.53	3.46
Av. dev., %			3.1	1.6	1.5*	3.6	4.9
4	5	0.33	3.78	3.78	3.77	3.76	3.76
	10	0.67	3.86	3.84	3.80	3.77	3.75
	15	1.03	3.98	3.94	3.84	3.77	3.73
	20	1.39	4.07	3.97	3.82	3.70	3.61
	25	1.75	4.15	4.01	3.76	3.57	3.45
	30	2.09	4.18	3.99	3.63	3.35	3.20
Av. S			4.00	3.92	3.77	3.65	3.58
Av. dev., %			3.2	1.9	1.3*	3.6	4.8
6	10	0.68	3.92	3.90	3.85	3.83	3.81
	15	1.08	4.17	4.12	4.03	3.95	3.91
	20	1.48	4.33	4.23	4.07	3.94	3.85
	25	1.87	4.43	4.28	4.02	3.82	3.69
	30	2.28	4.56	4.35	3.95	3.65	3.49
Av. S			4.28	4.18	3.98	3.84	3.75
Av. dev., %			4.4	3.2	1.7*	2.2	3.4
8	10	0.70	4.03	4.01	3.97	3.94	3.92
	15	1.09	4.21	4.16	4.07	3.99	3.95
	20	1.49	4.37	4.26	4.10	3.96	3.87
	25	1.93	4.58	4.42	4.15	3.94	3.80
	30	2.39	4.78	4.56	4.14	3.82	3.66
Av. S			4.39	4.28	4.09	3.93	3.84
Av. dev., %			5.2	3.9	1.3	1.1*	2.3
10	15	1.12	4.32	4.28	4.18	4.10	4.05
	20	1.56	4.57	4.46	4.29	4.15	4.06
	25	2.00	4.74	4.58	4.30	4.08	3.94
	30	2.43	4.86	4.64	4.21	3.89	3.72
Av. S			4.62	4.49	4.25	4.06	3.94
Av. dev., %			3.8	2.7	1.2*	2.0	2.9
12	20	1.63	4.78	4.66	4.48	4.34	4.24
	25	2.18	4.93	4.76	4.47	4.25	4.10
	30	2.68	5.36	5.12	4.64	4.29	4.10
Av. S			5.02	4.85	4.53	4.29	4.15
Av. dev., %			4.5	3.8	1.6	0.7*	1.5

*The asterisk marks the minimum variation in stiffness as a function of the bending angle.

* If one wishes to know the intrinsic stiffness of paper as a material, a [illegible]oretical value can be obtained by dividing by the cube of the thickness [illegible]ing the "bending modulus" of Peirce (*2*) and Hebeler *et al.* (*7*).

specimen was bent successively through the various angles, so that variation in the material does not affect the relative stiffness calculated for the various angles. However, to minimize accidental errors of observation, from 5 to 15 specimens were used, and the average value of k for each angle is shown in the table.

It is observed that S_1 increases with increasing θ, whereas S_6 decreases Somewhere in between there is a minimum variation in the stiffness values with bending angle. As a measure of this variation, the average percentage deviation from the mean stiffness value in each group is given. Where this deviation is a minimum one obtains, of course, the best choice of $f(\theta)$ for a given length. The minimum in each case is indicated by an asterisk. S_4 is most often the best choice in Table II, with S_3 next. However, there is observed a definite tendency for the minimum variation to shift to the right as the length of the specimen increases. Since the lower bending angles were omitted (in the interest of precision) in testing the greater lengths, it might be suspected that the shift is associated with the range of bending angles. Another set of tests of this paper was made at 10, 20, and 30° for all lengths. The same type of shift was shown, and the optimum expressions for $f(\theta)$ were $f_3(\theta)$ and $f_4(\theta)$ about equally often.

Somewhat similar data for several types of paper are shown in Table III, the variation with bending angle alone being given. The value for S_6 was calculated only when the minimum approached it closely. In some cases fewer specimens were used, but a given specimen was always bent through the three or more angles (usually 10, 20 and 30°). The tendency for the minimum variation (best agreement with changing bending angle) to shift to the right as the length increases is shown for all papers tested. Table IV summarizes the relative distribution of the minima. The

Table III. Data Showing the Position with Reference to $f(\theta)$ of the Minimum Variation of Stiffness as a Function of the Bending Angle in the Range 5° to 30°

Paper	L, cm.	Average per cent deviation of S_1	S_2	S_4	S_5	ϵ	S_2 (Av.) g.-cm.	E, p.s.i.
Newsprint, machine direction, d = 0.0089 cm.	2	2.0	0.7[a]	3.1	5.7	...	1.26	306 × 10³
	3	3.1	1.7	1.6[a]	4.2	...	1.33	...
3/4 rag map, machine direction, d = 0.0081 cm.	3	2.9	1.7[a]	1.9	4.6	...	2.39	767
	4	3.4	1.9	1.3[a]	3.9	...	2.51	...
	6	3.4	2.0	1.7[a]	4.0	...	2.67	...
	8	5.9	4.4	1.7	1.6[a]	2.9	2.75	885
3/4 rag map, cross direction	2	5.0	3.7	1.9[a]	3.3	...	1.36	438
	3	9.2	7.9	5.5	4.7	4.5[a]	1.40	...
	4	7.0	5.8	3.3	3.1[a]	3.3	1.48	480
All-rag bond, machine direction, d = 0.0094 cm.	3	1.7	0.4[a]	3.3	5.8	...	3.05	626
	4	3.4	2.1	1.2[a]	3.9	...	3.15	...
	6	4.2	2.9	1.4[a]	3.5	...	3.31	680
All-rag bond, cross direction	2	2.2	1.0[a]	2.9	5.6	...	1.60	328
	3	3.8	2.6	1.6[a]	4.1	...	1.69	...
	4	3.4	2.1	1.4[a]	4.0	...	1.75	360
1/2-rag bond, machine direction, d = 00091 cm.	4	3.8	2.6	1.4[a]	4.0	...	3.77	852
	6	4.3	2.8	0.4[a]	3.1	...	4.10	...
	8	7.2	6.0	3.5	2.8[a]	2.9	4.00	...
	12	9.0	7.5	4.5	2.5	1.1[a]	4.32	978
1/2-rag bond, cross direction	2	1.2	0.6[a]	3.8	6.3	...	1.73	390
	3	4.3	3.1	1.7[a]	3.8	...	1.79	...
	4	3.9	2.4	1.5[a]	3.7	...	1.91	...
	6	3.3	1.8	1.7[a]	4.0	...	2.05	463
Sulphite bond, machine direction, d = 0.0094 cm.	1.5	1.9	1.8[a]	2.0	5.5	...	3.30	677
	2	2.3	0.9[a]	2.1	4.4	...	3.63	...
	3	3.1	1.6	1.5[a]	3.6	...	3.82	...
	4	3.2	1.9	1.3[a]	3.6	...	3.92	...
	6	4.4	3.2	1.7[a]	2.2	...	4.18	...
	8	5.2	3.9	1.3	1.1[a]	2.3	4.28	...
	10	3.8	2.7	1.2[a]	2.0	...	4.49	...
	12	4.5	3.8	1.6	0.7[a]	1.5	4.85	995
Sulphite bond, cross direction	1.5	2.1	1.3	0.7[a]	1.5	...	1.87	384
	2	1.5	0.6[a]	1.5	3.1	...	2.04	...
	3	2.8	1.3[a]	1.9	4.1	...	2.15	...
	4	3.0	1.8	1.4[a]	3.1	...	2.24	...
	6	4.1	3.1	1.4[a]	2.4	...	2.40	...
	8	4.9	3.9	1.4	1.1[a]	1.9	2.53	...
	10	4.7	3.7	1.4	1.3[a]	1.9	2.73	...
	12	4.2	3.4	1.6	0.4[a]	1.0	2.98	610
All-rag ledger, machine direction, d = 0.0127 cm.	2	0.4[a]	1.7	4.8	7.3	...	6.39	523
	3	3.2	0.6[a]	3.7	6.3	...	6.55	...
	4	3.5	1.0[a]	2.3	4.7	...	7.08	...
	6	2.7	1.3[a]	2.1	4.6	...	7.80	...
	12	5.4	4.7	2.3[a]	2.6	...	8.29	688
Kraft wrapping, machine direction, d = 0.0140 cm.	6	1.8	0.8[a]	2.9	5.3	...	10.8	673
	8	3.7	2.0	1.0[a]	3.6	...	11.2	...
	12	5.6	4.4	2.0[a]	2.3	...	11.7	725
Kraft wrapping, cross direction	3	1.9	0.3[a]	2.8	5.4	...	4.89	304
	4	2.2	1.0[a]	2.4	5.0	...	4.91	...
	6	4.6	3.3	0.9[a]	2.8	...	4.90	305
Rope manila, machine direction	8	3.0	1.5[a]	1.8	4.2	...	43.5	1310
	12	4.2	2.7	0.9[a]	3.2	...	45.4	1370
Rope manila, cross direction, d = 0.0178 cm.	2	2.2[a]	3.7	6.8	9.2	...	7.97	240
	3	0.2[a]	1.4	4.5	7.0	...	8.42	...
	4	2.4	0.9[a]	2.3	4.9	...	9.02	...
	6	3.3	1.8[a]	1.8	4.0	...	9.68	...
	8	3.1	1.7[a]	2.3	4.9	...	10.4	312

[a] Marks the minimum deviation for each case.

Table IV. Distribution of Minima of Table III with Reference to $f(\theta)$

cm.	$f_1(\theta)$	$f_3(\theta)$	$f_4(\theta)$	$f_5(\theta)$	$f_6(\theta)$
.5	0	1	1	0	0
2	2	5	1	0	0
3	1	5	4	0	1
4	0	3	7	1	0
6	0	3	7	0	0
8	0	2	1	4	0
10	0	0	1	1	0
12	0	0	3	2	1
Total	3	19	25	8	2

st agreement of stiffness values with changing bend- ng angle is obtained most frequently by the use of or $f_4(\theta)$, that is by dividing by the angle or by the ngent of the angle.

As a matter of interest, the stiffness average (S_3) the various bending angles is given in the next to last column of Table III for each length of specimen. is affords an idea of the range of stiffness of some of e ordinary types of paper. The last column shows me values of Young's modulus, E, obtained by equa- n (1), corresponding to the S_3 values.

It is somewhat surprising that the small-angle ex- ssions for $f(\theta)$ yield stiffness values so nearly constant en the angle alone is varied through such a large nge. Hebeler and co-workers (7) reported a some- at similar finding for angles as great as 60°, but no ta were given.

IFFNESS WITH VARIABLE WIDTH OF SPECIMEN

According to equation (1), for a given length, L, of ecimen bent through a given angle, θ, the bending oment, M, should be proportional to the width, b, of e specimen, in order to yield a constant value of stiff- ss as the width is varied. It would be very surprising this were not so. In Table V each group of three lues for a given specimen, having a common length l bent through the same angle, illustrates how well s expectation is borne out. The missing values rep- ent tests that could not be made within the limits the tester. Wide, short specimens bent through large gles required torques too great for the torque scale, d long, narrow strips bent through small angles pro- ced torques too small to be read accurately. The reement is very good within each group.

ble V. Effect of Width of Specimen on Stiffness of Paper Calculated as $ML/3b\theta$ (Sulphite Bond)

, b, cm.	Stiffness (S_3) at bending angles 5°	10°	15°	20°	25°	30°
2	3.24	3.36	3.20	...	...	...
4	3.28	3.37	3.37	...	...	...
6	3.21	3.33	...	...	...	...
2	3.52	3.58	3.64	3.69	...	...
4	3.49	3.58	3.64	3.65	...	...
6	3.54	3.62	3.60	...	...	...
2	...	3.73	3.82	3.89	3.91	3.86
4	3.55	3.70	3.82	3.85	3.87	3.84
6	3.69	3.70	3.76	3.79	...	...
2	...	...	3.95	4.02	4.02	4.04
4	3.72	3.85	3.96	4.00	4.02	3.96
6	3.77	3.84	3.93	3.93	3.99	3.96
2	...	...	...	4.28	4.33	4.44
4	...	3.88	4.17	4.25	4.33	4.38
6	...	3.96	4.07	4.18	4.23	4.22
2	...	...	...	...	...	4.65
4	...	...	4.20	4.32	4.50	4.60
6	...	...	4.13	4.25	4.37	4.42

Table VI. Average Stiffness Values (S_1) for Various Lengths of Specimen from Table II, Calculated First by Equation (1), and Then by the Same Equation with L Replaced by L to the 0.8 Power

L, cm.	$\frac{ML}{3b \sin\theta}$	$\frac{ML^{0.8}}{3b \sin\theta}$
1.5	3.37	3.10
2	3.71	3.24
3	3.87	3.11
4	4.00	3.03
6	4.28	3.00
8	4.39	2.90
10	4.62	2.92
12	5.02	3.05

STIFFNESS WITH VARIABLE LENGTH OF SPECIMEN

It would be expected from equation (1) that, for a given width and bending angle, the bending moment should be inversely proportional to the length of the specimen in order to yield a constant value of the stiffness as the length of the specimen is varied. But we have already seen in Tables II, III, and V that for a given bending angle the stiffness increases somewhat as the length of specimen is increased. It was found empirically that the torque varies approximately as the eight-tenths power of the length of the specimen. If, therefore, we should multiply the stiffness values in Table II by $L^{-0.2}$, we should obtain more nearly uniform values as the length is increased. Table VI illustrates this for the average S_1 values for each length. The exponent of L, however, will vary somewhat with different papers, different length intervals, and different forms of $f(\theta)$, ranging usually between 0.7 and 0.9.

CONCLUSION

With a sensitive instrument designed to apply a measured torque to a specimen of paper of variable dimensions, stiffness measurements were made of several kinds of paper, the length and width of specimen and the bending angle being varied within convenient limits.

The expression chosen to evaluate stiffness, based on the equation for the elastic deflection of cantilever beams, yields an approximately constant value for stiffness when the width and bending angle are varied. However, when the bending length is varied this expression gives values for stiffness that increase somewhat as the length is increased. A nearly constant value of stiffness is given by the following modification:

$$S = \frac{ML^n}{3b} f(\theta)$$

in which n is in the neighborhood of 0.8, and $f(\theta)$ may take on any one of several prescribed forms, but is most often the reciprocal of the bending angle or of its tangent.

The simple approximate expression

$$S = \frac{ML^{0.8}}{3b\theta}$$

appears to be adequate for the evaluation of the stiffness of most papers.

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Received Oct. 30, 1952. Published in the December, 1952, issue of the *Journal of Research of the National Bureau of Standards.*

The authors wish to express their gratitude to Norman H. Ditrick, student guest worker during the summer of 1951, for valuable assistance in obtaining data and making calculations.

A Liquid Penetration Test for Measuring the Sizing of Paper

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Quantitative ratings of the sizing of paper samples can be obtained readily by a test based on reflectance or transmittance measurements made on the sheet during penetration by a test liquid. The test is more precise than most sizing tests and gives closely reproducible results. It can be made with nearly any liquid as the penetrant, but the penetrant should be chosen with care because it must have the proper wetting power for the sample of paper which is to be tested. After the proper conditions have been established, the test can be shortened by making single transmittance or reflectance measurements. Under these conditions the test is convenient and quite rapid.

In order to determine quantitatively the relative sizing of different samples of paper, it is necessary to have a sizing test which gives reproducible results and which is primarily a measure of resistance to penetration by liquids. The test values should vary in a manner correlatable with the average advance of penetrant through the paper, and be interpretable in terms of sizing, regardless of the effects that other paper properties have upon the test values. One test which meets these requirements is based on changes in the optical properties of the sheet during penetration by the test liquid. The measurements are made with a specially designed photometer. Small differences in sizing can be distinguished and, because the visual determination of an end point is not required, the variability of an operator's judgment is eliminated. The test is also quite versatile and can be used with a variety of test liquids.

In this test, measurements of transmittance or reflectance are used to follow penetration by the test liquid. When paper is wetted by a transparent liquid such as water, oil, or various aqueous solutions, its optical transmission of light increases; therefore, measurements of the rate of increase of light transmittance during penetration can be used to determine the rate of penetration of the liquid. When a highly colored liquid like ink is poured onto the surface of a sheet, the reflectance of the undersurface decreases as the ink penetrates. In this case, measurement of the rate of decrease of reflectance can be used to follow the penetration of the ink. Thus, by using either reflectance or transmittance measurements, the penetration of most liquids can be followed.

Figure 1 is a schematic diagram of the instrument. Light from a tungsten projection lamp passes through a filter and condensing lenses into an integrating sphere where it is diffusely reflected. The sample of paper being tested is placed in a holder which fits on the top of the sphere. The undersurface of the paper is illuminated by the light which has entered the sphere, and the reflectance of its undersurface can be measured by a photocell in the bottom of the sphere. The transmittance of the sheet can be measured by a second photocell in an integrating sphere which is mounted above the sample and collects the light transmitted through the paper. A zero-potential photometric circuit is used, and this requires a third photocell which views the lamp directly. When integrating spheres are used in this way, the instrument measures diffuse reflectance or diffuse transmittance, the latter of which is necessary for a theoretical interpretation of the data. The use of diffuse illumination also reduces the effect of the gloss of the paper sample. The use of a filter to give essentially monochromatic light minimizes the effect of the color of the paper.

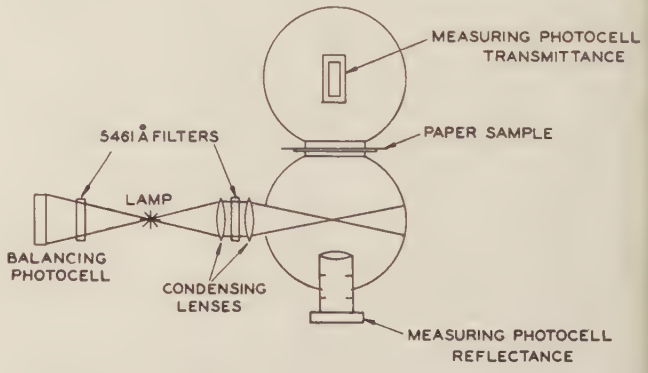

Fig. 1. Schematic diagram of photometer

In carrying out the tests, the paper sample is placed in the holder and the measuring photocell is balanced against the cell which views the lamp. Then a measured amount of the test liquid is poured onto the paper and a stopwatch started. As the amount of light reaching the measuring photocell changes, the circuit is

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ot in balance by changing variable resistors cali-
ted to read directly either per cent relative reflect-
ce (based on reflectance of the dry paper) or per cent
olute transmittance (based on light transmittance in
e absence of the paper sample).

Fig. 2. Photograph of the complete apparatus

Figure 2 is the photograph of the complete apparatus
owing the light source and integrating spheres, the
ntrol box, the galvanometer, and the sample holders.
e two measuring photocells are connected to their
pective binding posts on the control box and either
n be connected in the circuit by means of a switch on
box. The photograph shows the top sphere in
sition for making transmittance measurements.
e funnel is used for introducing the test liquid.
hen reflectance measurements are being made, only
bottom sphere is needed, and the top sphere is
ing back. In this case, stray light from the room is
luded by placing a black cone over the sample (see
er left corner of the photograph). This is essential
en reflectance measurements are made with trans-
ent liquids. The sample holder is shown in detail in
ure 2. By having several optically identical sample
ders, and cleaning the extra ones while one is being
d for the test, it is possible to carry out the tests
most as rapidly as the liquid penetrates. For re-
ducible results it is necessary to use the instrument
a constant-temperature, constant-humidity room.

Figure 3 illustrates the type of curve obtained by
tting the transmittance of a sample of paper against
e. In this case, 0.3% hydrochloric acid was used as
penetrant. The curve can be readily divided into
o rather distinct straightline portions. By analogy
h similar curves obtained at The Institute of Paper
emistry (*1, 2*) in work on oil penetration, the steeper
tion can be interpreted as due to penetration of the
es of the sheet, i.e., filling the spaces between the
rs with liquid. The more gradual change in trans-

mittance which follows is then due to the slower process of saturating the individual fibers.

In the cited work on oil penetration, a mathematical interpretation of the curves was developed. This interpretation is based on the exponential law of absorption and is equally applicable to water penetration. Some distortion may be introduced by the fact that cellulose is a hydrophilic material. The essential relationships are as follows:

If

T = per cent diffuse transmittance of paper
T_o = initial diffuse transmittance (test liquid on paper)
T_T = diffuse transmittance of paper at transudation with pores filled with test liquid but fibers unpenetrated
u_1 = absorption coefficient of dry paper covered with liquid
u_2 = absorption coefficient of paper with pores filled with test liquid, but fibers unpenetrated
x = distance average liquid front has penetrated into the paper
l = thickness of paper

Then

$$T = T_o e^{(u_1 - u_2)x} \tag{1}$$

From this it follows that:

$$x = \frac{1}{u_1 - u_2} \ln \frac{T}{T_o} \tag{2}$$

$$l = \frac{1}{u_1 - u_2} \ln \frac{T_T}{T_o} \tag{3}$$

$$x = \frac{l}{\ln \frac{T_T}{T_o}} \cdot \ln \frac{T}{T_o} = \frac{l}{\ln \frac{T_T}{T_o}} (\ln T - \ln T_o) \tag{4}$$

$$\frac{dx}{dt} = \frac{l}{\ln \frac{T_T}{T_o}} \frac{d}{dt} \ln T = \frac{l}{\ln \frac{T_T}{T_o}} \cdot \frac{1}{T} \frac{dT}{dt} \tag{5}$$

or

$$\frac{dT}{dt} = aT \frac{dx}{dt} \tag{6}$$

where a is written for $\ln (T_T/T_o)/l$.

Equation (6) indicates that the slope of the T versus t

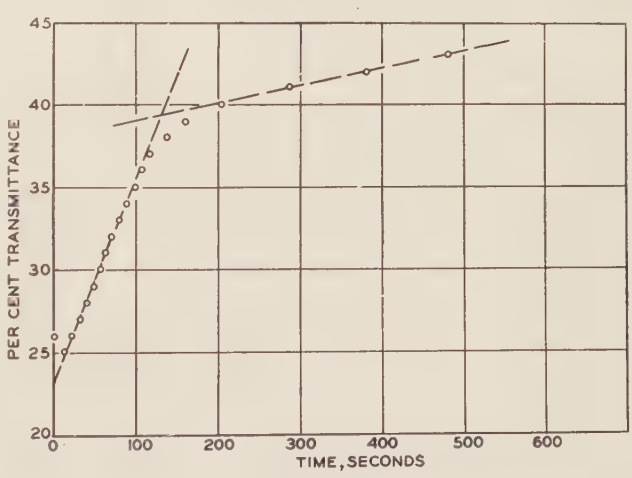

Fig. 3. Typical transmittance-time curve for 40-lb. handsheet

curve should increase with increasing T. This is evident in the portion of the curve of Fig. 3 between $t \cong 10$ sec. and $t \cong 60$ sec. However, complete penetration soon occurs in some spots, slowing up the average rate

of transudation, and hence decreasing dT/dt. At t = 60 sec. the effect on the curve due to the slowing of the average rate of transudation predominates. These two opposing phenomena give the T versus t curve a characteristic S shape.

The hypothesis on which the experimental work herein reported is based is that during pore penetration the transmittance change is relatively small. Hence an average dT/dt measured at the left of the point of inflection may, for all practical purposes, be considered as a measure of the average dx/dt.

T_o is obtained by extrapolation of the T versus t curve to zero time, and T_T is obtained by finding the intersection of the two straightline portions of the curve. The value for dT/dt is obtained from the slope of the steep portion of the curve, and the thickness, l, is measured. The rate of penetration dx/dt is then calculated from equation (5). Samples are compared on the basis of the values obtained for the rate dx/dt. Transudation times can also be used as a basis of comparison if the samples are of equal thickness or if the thickness variations are taken into account.

Although tests can be made with a variety of penetrants, choice of penetrant is quite important. Figure 4 illustrates the effect of rosin size concentration on transmittance-time curves obtained with distilled water as the penetrant. The upper curve, which is for paper sized with 0.5% rosin size, is very similar to the curve shown in Fig. 3 and can be used to determine a transudation time and a rate of penetration. However, in the sheets made with larger quantities of size, pore penetration is so slow that it is not easily distinguishable from fiber penetration. It is not possible to draw lines through two straight portions or to determine a point of intersection; therefore, an interpretation of the curves in terms of rate of penetration and transudation time is impossible. Furthermore, even after soaking in water for 4 days, the transmittance of the paper containing 2% size increased only to 35%. Since the transmittance of an unsized sheet from the same pulp furnish increased to 69% on wetting, it is apparent that the sized sheet was sufficiently well sized to prevent

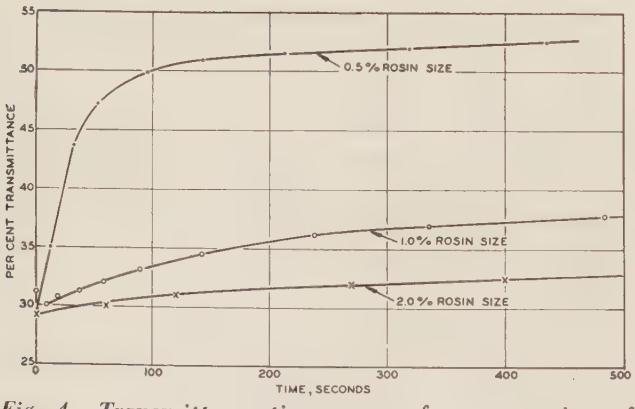

Fig. 4. Transmittance-time curves for penetration of sized sheets by water

water from entering the small capillaries in a reasonable time.

Papers containing larger amounts of size require even longer times for penetration by water, and the transmittance values ultimately attained are proportionately lower. The changes in the transmittance of these sized sheets are so small that they are not very useful in determining relative sizing. The testing of well-sized papers by this method, therefore, requires a penetrant with greater wetting power than water.

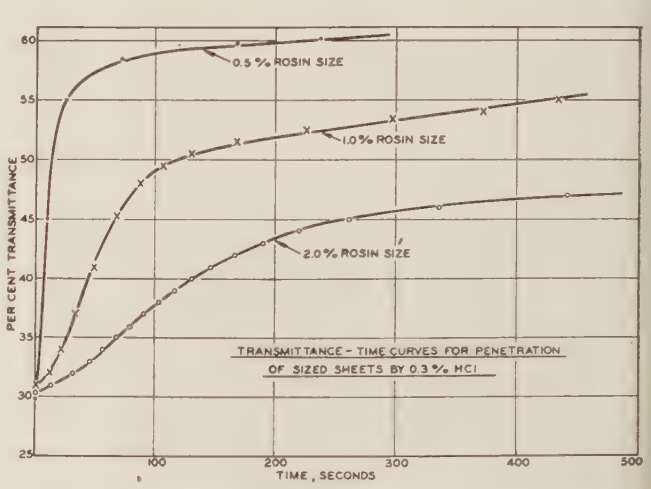
PER CENT TRANSMITTANCE
TIME, SECONDS
0.5% ROSIN SIZE
1.0% ROSIN SIZE
2.0% ROSIN SIZE
TRANSMITTANCE - TIME CURVES FOR PENETRATION OF SIZED SHEETS BY 0.3% HCl

Fig. 5. Transmittance-time curves for penetration of sized sheets by 0.3% HCl

Dilute hydrochloric acid has sufficient wetting power to be useful for most evaluations of rosin-sized papers and a solution of 0.3% concentration has been used. Figure 5 presents curves for the penetration of these same samples of paper by 0.3% HCl, and these latter curves can be used to calculate rates of penetration.

In this case the faster rate of penetration by HCl is due to the wetting action of the acid on the rosin-aluminum complex, which is the actual sizing agent. For papers which give measurable rates with both water and dilute acid, 0.3% HCl penetrates about three times as fast as water. It has been suggested that the transmittance increases more rapidly with dilute HCl because it penetrates the fibers more completely than water; however, when unsized bleached sulphite handsheets were soaked in water and in 0.3% HCl for 2, 6, and 24 hr., the transmittance of the saturated paper was the same for both liquids. In fact, it was found that the time necessary for saturation of the fibers was slightly longer for HCl penetration, as would be expected from the tendency of dilute acids to repress the water swelling of cellulose fibers.

In the case of easily sized pulps, even 0.3% HCl does not have sufficient wetting power for the types of paper usually encountered. In some tests this difficulty has been overcome by using 20% lactic acid as the penetrant. However, strong acid causes hydrolysis of the rosin size precipitate and, although many commercial inks are quite acidic, most use requirements are based upon resistance to penetration by water rather than ink. On handsheets sized with the same sizing agent, water, 0.3% HCl, and ink containing 0.3% HCl give the same relative ratings, but when different sizing agents are compared, an acid penetrant may give quite misleading results. For example, using an acid ink or 20% lactic acid to compare rosin-sized papers with wax-sized papers may give a falsely high value for the paper containing wax. The acid attacks the rosin-aluminum

plex chemically but does not affect the wax. Thus, although acid penetrates the rosin-sized paper faster than the wax-sized paper, the relative rates of penetration of the two papers by water may be quite different. For these reasons it seems desirable to use a pene-

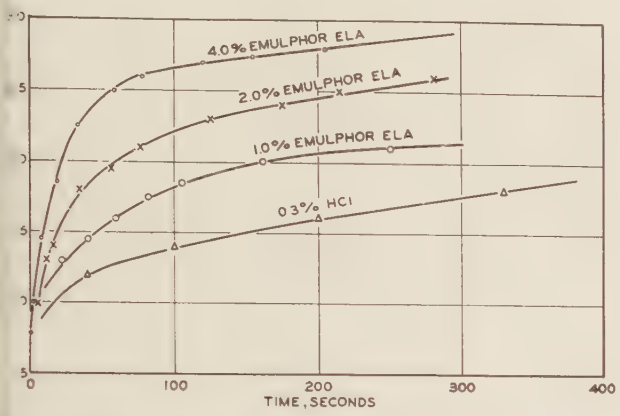

Fig. 6. Effect of wetting agent concentration on penetration rate

rant whose wetting action does not depend on chemical reaction with the sizing material. An aqueous solution of some nonionic surface-active agent seems a logical choice. One which has been investigated is Emulphor ELA (General Chemical Co.), and Fig. 6 shows the effect of Emulphor concentration on the curves obtained for unbleached kraft handsheets sized with 0.5% rosin size.

The transmittance of a waterleaf from this same pulp was increased from 12.9% dry to 39.0% on saturation with water and to 42.5% on saturation with 0.3% HCl. The slightly higher transmittance in the case of 0.3% HCl is due to bleaching of the pulp by the acid. The inadequacy of 0.3% HCl as a penetrant for paper containing 0.5% rosin size is shown by the fact that, after soaking a sample 7 days in 0.3% HCl, its transmittance increased only to 26.8%, compared with 42.5% for the waterleaf. Soaking in acid increased the transmittance of the sized sheet only half as much as it increased that of the waterleaf. Treatment with 4% Emulphor ELA solution raised the transmittance to 40.8%, which is approximately the value for the wet waterleaf. On this basis, the 4% solution of Emulphor ELA should be a satisfactory test liquid for this paper.

Rates of penetration based on transmittance measurements can be made only on samples which transmit a moderate amount of light. The instrument is not sensitive enough to give satisfactory transmittance-time curves if the transmittance values for the saturated sheet are lower than 15 to 20%. Reflectance measurements with ink can be made on heavier sheets but, because there is usually an appreciable time before the penetrating liquid appears on the undersurface, the significance of the test is quite different and the advantages of photometric measurement are not so great. When reflectance measurements are used, the test is similar to the news ink test described by Hammond (*3*) and carried out with the instrument manufactured by Sarss, Knobel, and Young of Cambridge, Mass.

Figure 7 illustrates reflectance-time curves obtained for the samples in Figs. 4 and 5. These data were obtained by measuring the decrease in reflectance during penetration by ink containing 0.3% HCl. These curves also have two straightline portions; however, there is no simple basis on which reflectance measurements can be used to determine transudation times and rates of penetration. The intersection of lines drawn through the two straight portions of the curve gives a value which approximates the transudation time, but the values obtained in this way for ink containing 0.3% HCl are about 1.3 times as large as transudation values obtained for 0.3% HCl by transmittance on the same papers. The larger values for transudation obtained using ink are probably due to the lower reflectance value of ink-saturated paper compared to acid-saturated paper, i.e., due to the colored ink appearing on the reflecting surface. When 0.3% HCl is used, the transudation times from reflectance and transmittance measurements are the same, and the slope of the reflectance versus t curves for 0.3% HCl and ink containing 0.3% HCl are approximately equal. Because the interpretation of transmittance measurement values is more straightforward than interpolation of reflectance values, the former are preferred for theoretical work.

For most of the sizing comparisons made with the photometer, it is possible to shorten the testing procedure considerably by making single-point measurements, i.e., determining the time required for reflectance to decrease to a specified value during penetration by ink. Reflectance measurements are simpler to make because only the bottom sphere is needed. For routine work, a single point on the curve is sufficient, instead of determining the whole curve. Although arbitrary end points may be misleading and give distorted values when the physical properties of the papers being tested differ greatly, it can be shown by analysis of reflectance-time curves that single-point reflectance measurements give quantitative comparisons if two requirements are met: (1) the papers tested must not differ greatly in thickness, opacity, or sizing, and (2) the end point chosen must be

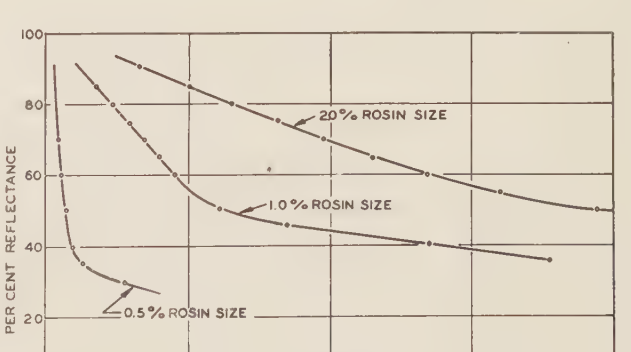

Fig. 7. Reflectance-time curves for penetration of sized sheets by acid ink

on the straightline portion of the reflectance-time curves for all of the paper samples being compared.

When, for example, the effects of different amounts of size on the sizing of a certain pulp are being compared, or if the effect on sizing of a papermaking variable (e.g.,

pH) is being determined, all the papers being tested will usually have the same thickness and opacity. In this case single-point determinations will give valid comparisons if the end point chosen is on the straight-line portion of all the curves. Control testing of a single grade of paper, for example, involves testing under these conditions. However, when comparing the sizing of papers from a pulp at different freenesses, single-point measurements give distorted values because freeness affects both thickness and opacity. The more transparent the paper is, the shorter the distance an average ink front has to travel before the reflectance decreases to a specified value. Likewise, the thinner the paper, the shorter is the distance that must be penetrated before the end point is reached. This means that the thinner (or more transparent) of two papers may give the lower single-point test values, even though the actual rate of penetration of the test liquid through it is slower.

Distortion by varying thickness and opacity is illustrated in Fig. 8. The single-point values for the papers at the two higher freenesses are approximately proportional to the transudation times and lie on a line passing through the origin. However, if the transudation times (which have been corrected for variations in sheet thickness) are assumed to give the correct ratings of sizing, the rating of the lowest freeness paper by a single-point reflectance measurement is about 30% too low. Here the extreme differences in thickness and opacity are 11 and 6%, respectively. When different pulps or pulp types are being compared, the physical properties of the sheets will differ to an even greater extent, and single-point measurements may result in considerable distortion of the true relative sizing.

When all of the factors are considered, correlation between these photometrically measured penetration tests and other frequently used sizing tests is usually good. The advantages for the photometer are that the data can be interpreted more completely with increased assurance that the values obtained represent the relative degrees of sizing of the samples tested. The use of penetrants of different wetting power makes it possible to test samples of various degrees of sizing, for (as this work shows) no single penetrant can be used satisfactorily for all the papers encountered. For example, in the testing of papers containing varying amounts of rosin size, water absorption tests and water penetration tests, such as the fluorescent size test or the TAPPI dry indicator test, give practically the same test values for all samples above a certain level of sizing. This is to be expected from the nature of the transmittance-time

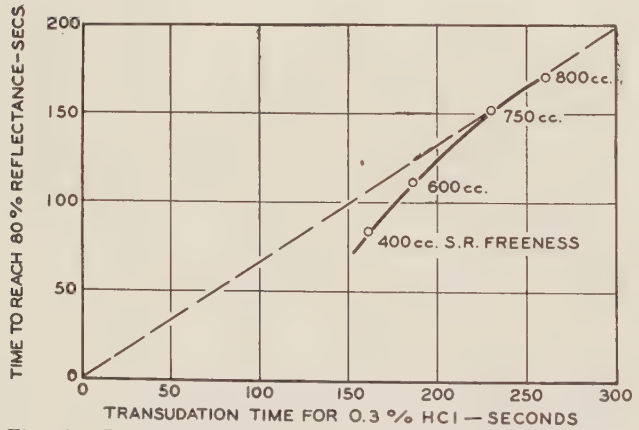

Fig. 8. Distortion of sizing ratings by thickness and opacity changes

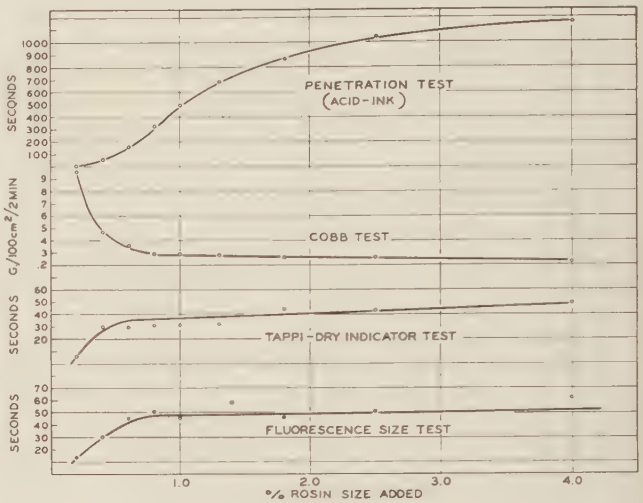

Fig. 9. Per cent rosin size added

curves obtained with water and does not mean that there are no differences between the samples or even that, after a certain sizing level has been reached, there is little difference in behavior toward water. However, above a certain sizing level, the effect of water on the secondary property (e.g., transmission of light) that is being measured by the various tests is small, and the variation between individual samples is great enough to mask differences in sizing. Using a liquid with greater penetrating power gives more reproducible differences in test values. An illustration of this is given in Fig. 9, in which various test values are plotted against size concentration for a set of handsheets which are identical except for amount of size added.

In order to determine quantitatively the relative sizing of papers, it is therefore necessary to use a suitable test liquid and to choose a proper end point. This is also true of other sizing tests. The advantage of this penetration test is that an analysis of the complete transmittance-time or reflectance-time curves reveals whether the test liquid has the proper wetting power and also affords a basis for choosing an end point. After proper conditions have been established, the photometer provides a convenient method of carrying out the tests and gives values which are reproducible and precise enough to distinguish relatively small differences in sizing.

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1. The Institute of Paper Chemistry, *Paper Trade J.*, *TS* 107, 210–212 (1938).
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3. Hammond, J., *Paper Trade J.* 103, No. 21, 37–39 (Nov. 19, 1936).

Received Dec. 12, 1951. Presented at the 36th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

Guar Mannogalactan Studies

I. *Purification and Characterization of Purified Fraction*

ARTHUR J. HAUG

A purified fraction of the mannogalactans from commercial guar mucilage was prepared by a specially developed hot water extraction and centrifuging technique. This fraction amounted to 76% of the original mucilage. The purified material was extensively characterized by means of physical and chemical analyses which should serve to aid future investigators in this field. Summative analyses accounted for 98.5% of the purified mucilage.

NATURE has produced a material known as a mannogalactan which has the properties that make "pouring hydration out of a barrel" possible for papermakers. This substance is a polysaccharide which on hydrolysis yields two hexoses—namely, mannose and galactose. The interesting and valuable mannogalactan mucilages are found in the seeds of many different legumes. Up to the present time the largest source of mannogalactan material has been the locust bean seed from the carob tree (*Ceratonia siliqua*), a perennial legume from the Mediterranean area. Among various sources is the guar seed (*Cyamopsis tetragonaloba*), an annual from India and, currently, the southwestern United States.

The seeds are held in small slender pods about 2 in. long which are borne by the stalk.

Although the guar plant was introduced into this country by the United States Department of Agriculture in 1903 (*1*), only in the last five or six years has it become the object of special interest. Because the war prevented locust bean flour importations, investigations were carried out by The Institute of Paper Chemistry to find a satisfactory domestic source of mannogalactan. The mannogalactan from the guar seed was found to have suitable properties for use in the paper industry. The southwestern United States offered a satisfactory agronomical environment for the plant and here successful plantings and harvestings have been made. The cooperative efforts of the United States Department of Agriculture, the University of Arizona, General Mills, Inc., and The Institute of Paper Chemistry in the development of this guar program have been reported by Rowland (*2*).

The guar seed is composed of three main sections: (1) the seed coat, an extremely hard covering or hull; (2) the embryo, a section rich in protein and oil; and (3) the endosperm located between the embryo and seed coat. The endosperm contains the mannogalactan mucilage as well as small amounts of minerals, fibers, and protein.

Mucilages or gums* are divided into the nonpolyuronide and the polyuronide classes. The mannogalactans are classified in the nonpolyuronide class because essentially only mannose and galactose are obtained on hydrolysis. The polyuronide mucilages, however, on hydrolysis all yield one or more of the following: hexoses, pentoses, and methylpentoses. Table I presents a summary of the mannose to galactose ratios of the various plant mucilages.

Table I. Analyses of Plant Mucilages

Source of mucilage	*Ratio of D-mannose to D-galactose*	*Analyst*
Carob seed	5.1:1	Bourquelot and Herissey (*5*)
Carob seed	3.5:1	Lew and Gortner (*6*)
Carob seed	2.6:1	Williams (*7*)
Carob seed	3.7:1	Wise and Appling (*8*), Anderson (*9*)
Carob seed	4.0:1	Iglesias (*10*)
Guar seed	1.6:1	Wise and Appling (*8*), Anderson (*9*)
Fenugreek seed	1.1:1	Daoud (*11*)
Lucerne seed (*Medicago sativa*)	0.5:1	Hirst (*12*)
Palo verde seed	3.4:1	Wise and Appling (*8*), Anderson (*9*)
Tara seed	2.7:1	Wise and Appling (*8*), Anderson (*9*)
Huizache seed	2.5:1	Wise and Appling (*8*), Anderson (*9*)
Honey locust seed	2.6:1	Wise and Appling (*8*), Anderson (*9*)
Kentucky coffee seed (*Gymnocladus dioica*)	2.7:1	Wise and Appling (*8*), Anderson (*9*)
Flame tree seed	4.2:1	Wise and Appling (*8*), Anderson (*9*)
(*Sophora japonica*)	5.2:1	Wise and Appling (*8*), Anderson (*9*)

In order to produce a product from guar mucilage which is suitable as a tub sizing adhesive, it is necessary to degrade the polymer. A patent by Swanson (*3*) covers a process for the conversion of guar mannogalactan in the presence of borax with sodium hypochlorite for this purpose. This oxidation procedure, together with the lack of fundamental studies with a purified guar mucilage, gave impetus to and formed the basis of the present work.

This paper deals with the purification of the commercially available mucilage preparatory to the characterization of the purified material by chemical and physical means.

Heyne and Whistler (*4*) have reported on the purification of guar mannogalactan. The analysis of the starting product (in per cent) was as follows: nitrogen 0.67, phosphorus 0.06, ash 1.07, water soluble 86.50, water insoluble 7.75, and alcohol soluble 1.50. The amount of water-soluble material was determined by autoclaving the starting product at the natural pH and then supercentrifuging the resulting dispersion. Analysis of the water-soluble fraction (in per cent) was as fol-

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* The term "gum" is used interchangeably in industry with mucilage, although "gum" is strictly reserved for pathological and mucilage for physiological plant components. Both terms will be used in this paper.

lows: uronic acids 0.0, pentosans 1.0, glucose (as saccharic acid) 0.0, galactose (determined as mucic acid) 38.4, and mannose (determined as the phenylhydrazone) 54.5. In *N* sodium hydroxide, the optical rotation was $[\alpha]_D^{25} + 53.6°$.

A rather complete survey of the mannogalactan literature has been presented by March (*13*), Yirak (*14*), and Haug (*15*).

PURIFICATION OF STARTING MATERIAL

The mannogalactan from the guar seed, *Cyamopsis tetragonoloba*, was chosen for this work because of the present commercial application and interest and because of its availability. For several years, a large agronomical project on the planting and harvesting of the guar plant has been underway in the southwestern part of the United States.

The finely powdered technical grade of guar mucilage had a very light gray cast. Though relatively pure, this commercial product contained some proteinaceous material, inorganic salts, water-insoluble gum, cell membranes, and traces of oils from the embryo.

The raw material had an ash content of 0.62% as determined by ignition of the gum in a muffle. Employing the Hengar semimicronitrogen technique (Institute method 705c), 0.31% nitrogen was found.

There are three possible sources of nitrogen in the commercial product. One is from the gum cell membranes, another from the incomplete separation of the embryo and endosperm (the embryo represents almost 50% of the seed and is largely protein), and the third from the center of the individual cells which are near the embryo in the seed. Probably the original 0.31% nitrogen of the guar is derived from all three of these sources.

Into 2800 ml. of vigorously stirred distilled water, 23 grams of guar mucilage were dusted very slowly. Because of the extremely hydrophylic nature of the material, hydration takes place instantly on the surface of a large clump of the material, forming a glob or ball; this either prevents or greatly retards dispersion of the material. The solution was heated directly by steam to 90°C. and maintained at this temperature with stirring for 20 min. The hot dispersion was run through a Sharple's supercentrifuge rotating at 25,000 r.p.m. to remove the undispersed gum, cell membranes, embryo, and seed coat. This debris was removed from the sides of the centrifuge rotor and stored in absolute ethanol.

After cooling, the gum was precipitated by pouring the centrifuged dispersion (approximately 0.6% concentration) into 2.5 times its volume of vigorously stirred 95% ethanol. The white, stringy gum was filtered on a Buchner funnel, using a Bird's Eye diaper cloth, and was finally squeezed by hand in the cloth. Approximately 25% of the alcohol-wet gum was saved and stored in absolute ethanol.

The remaining part of the gum was redispersed in water with the aid of a Waring blendor. The dispersion was heated by directed steam to 80°C. and maintained at that temperature for 20 min. with agitation. Because a very small amount of undispersed material was discernible, the hot dispersion was again passed through the supercentrifuge at a concentration of approximately 0.7%. The undispersed material was recovered and stored in absolute ethanol.

The mucilage was precipitated from the cool centrifuged dispersion by pouring slowly into agitated ethanol in the same manner as described above. About 33% of the remaining gum was separated and stored in absolute ethanol.

The same procedure was repeated twice, omitting the centrifuging step each time. In this manner, a product was obtained which had been precipitated three times, as well as one that had undergone four precipitations.

Treatment of the four purified products and the two nondispersed fractions was as follows. The material was thoroughly triturated in a mortar with absolute ethanol and filtered on a Buchner funnel, using paper. A rubber dam was used to more completely remove the liquid from the gum in each filtration. After a second trituration with absolute ether, the sample was filtered and allowed to stand in absolute ether for several hours to complete the dehydration. After a final filtration, the sample was conditioned in the air for 3 to 4 hr. Complete dehydration of the gum prior to the conditioning was essential. Without complete dehydration, the gum forms a dark gray, extremely hard, horny mass which resists grinding and redispersion into water.

The four purified products were a bright white, as contrasted with the undispersed material from the first dispersion, which was slightly darker than the original guar product. The small amount of undispersed residue recovered from the second dispersion was dark gray. The first insoluble fraction amounted to 17% of the original gum, whereas the second fraction was only 0.2%.

Table II. The Effect of Repeated Precipitations on the Ash and Nitrogen Contents of Guar Gum

Product	*Moisture,* %	*Ash,*[a] %	*Nitrogen,*[a] %	*Protein*[a] (% *N* × 5.7), %
Original raw material	9.19	0.62	0.31	1.77
Precipitated once	5.81	0.07	0.14	0.80
Precipitated twice	8.22	0.07	0.11	0.63
Precipitated three times	7.53	0.07	0.09	0.51
Precipitated four times	6.52	0.08	0.11	0.63

[a] All values on ovendry basis.

The effect of the repeated precipitations on the ash and nitrogen contents is shown in Table II. All analyses were run in duplicate.

Using larger quantities of mucilage, the procedure outlined above was carried out to obtain suitable quantities of two undispersed fractions for analysis. Each fraction was dehydrated in the same manner as that used with the purified gum. The fractions were characterized by ash and nitrogen determinations (Table III).

Table III. Ash and Nitrogen Determinations on Undispersed Fractions of Gum

Product	*Ash,* %	*Nitrogen,* %	*Protein* (% *N* × 5.7), %
Undispersed fraction from the first centrifuging	0.44	0.77	4.38
Undispersed fraction from the second centrifuging	2.18	1.88	10.70

The data in Table II justified the use of only two precipitations in purifying the guar mucilage used in this work. The following directions apply to the procedure developed for the preparation of the purified material:

1. Weigh out 79 grams of mucilage (72 grams, oven dry).
2. Dust carefully into 9 liters of distilled water which is being vigorously agitated.
3. Heat to 90°C. with direct steam and hold for 20 min at this temperature.
4. While hot, pass the dispersion through the supercentrifuge.
5. Cool the centrifuged dispersion to approximately 20°C.
6. Precipitate the mucilage by pouring the dispersion into 26 liters of 93–95% ethanol with agitation.
7. Filter through cloth and press by hand.
8. Place in absolute ethanol and disintegrate in the Waring blendor for about 20 to 30 sec.
9. Filter on a Buchner funnel using paper.
10. Allow to stand in absolute ether at least 10 hr.
11. Filter, spread in a large Petri dish, and condition in the humidity room at 50% R. H. and 71°F. overnight.
12. Store in a stock bottle.

The size of the batch was limited to approximately 79 grams by the equipment on hand. Larger amounts of gum would have required exorbitant amounts of alcohol, since the volume ratio of dispersion to alcohol of 1:2.5 must be maintained to insure complete precipitation. The maximum gum concentration possible in the procedure is about 0.7%. Above this value, handling would be difficult and flow through the supercentrifuge and efficiency of centrifuging would be impaired.

Conditioning the purified gum in the humidity room was found to eliminate any difficulty encountered in grinding. Little or no static electricity was developed when a sample conditioned in the humidity room at 50% relative humidity was ground in a mortar and pestle.

The alcohol used in this study was reclaimed by distillation in 100-gal. batches in a large semicommercial still. In each run, sodium hydroxide was added to the kettle to prevent distillation of any volatile acids that might have been present as impurities.

Yield determinations were made on five successive batches; the results obtained are presented in Table IV.

Table IV. Yields of Purified Gum and Undispersed Fractions Obtained in Purification Procedure

	Batch No. 1	2	3	4	5
Purified gum, %	76.3	76.4	76.4	76.1	77.4
Undispersed fraction, %	...	17.9	17.8	17.9	16.5

All the purified mucilage was a "fibrous-like" form; to insure ease of redispersion and handling, it was ground to a fine powder. Milling with stainless steel balls in a porcelain jar was without effect on the ash content of the mucilage.

When the grinding operation was complete, all the purified material was well mixed on a large piece of paper. By the method of quartering, about 140 grams of material were obtained as a representative sample and this material was used for the characterization of the purified starting material. In all, about 69 batches of gum were purified and approximately 4000 grams of air-dry mucilage were obtained. The material was stored in airtight containers.

CHARACTERIZATION OF PURIFIED FRACTION

Ash Determination

The purified gum was nearly free from inorganic material. The ash content was found to be only 0.08% (oven-dry basis), using the microtechnique for ash determination by ignition.

A spectrographic analysis of the ash was made by the Physics Department. Approximately 5 grams of pure gum were ignited in a platinum crucible in a muffle. The composition of the ash is given in Table V.

Table V. Spectrographic Analysis of the Ash from Purified Mucilage

Strong	*Medium*	*Weak*	*Trace*
Ca	Cr	Mn	Mo
Mg	Sr	Al	Co
	Cu	Fe	Zn
	P	Pb	Li
	B	Na	Rb
		Cd	
		Sn	
		Si	
		Ni	
		Ag	
		K	
		Ba	

The analysis of the ash was found to be qualitatively identical in composition with that of the ash from the first undispersed fraction obtained in the centrifuging operation.

Nitrogen Determination

The nitrogen content of the purified gum was obtained by using the Hengar method. A value of 0.10% nitrogen was obtained.

Determination of Relative Viscosity

The relative viscosity was obtained on dispersions at two concentrations, 0.202 and 0.745%. An Ostwald viscometer with a water constant of 4.5 sec. at 29.8°C. was used for the determinations. Duplicate determinations were made at 29.8°C.

Using the relation

$$\eta_{rel} = t \text{ dispersion}/t \text{ water}$$

where

η_{rel} = the relative viscosity
t = the time in seconds

the relative viscosities were 6.14 for the 0.202% dispersion and 602 for the 0.745% dispersion.

Determination of Optical Rotation

A dispersion of the mucilage was made with distilled water and enough 30% sodium hydroxide was added to make a 3.5% or 0.90 N solution. A reading of +1.30 sugar degrees (+0.45 circular degree) was obtained with a 0.40% dispersion in a 2-dm. tube. A Bausch & Lomb saccharimeter equipped with a Lippich polarizer and a "D" line filter was used.

Employing the formula

$$[\alpha]_D^{30°} = \frac{100\alpha}{lc}$$

where

$[\alpha]_D^{30°}$ = the specific rotation in degrees
α = the observed angle in circular degrees
l = the length of the tube in decimeters
c = the concentration of gum in grams/100 ml.

the specific rotation was found to be +56.5°. This value was confirmed, within a few degrees, by many determinations at lower concentrations.

The optical rotation of a 0.88% dispersion of the mucilage in 2.5% hydrochloric acid was obtained. The dry gum was dispersed in hot water and shaken until dispersion was complete. After addition of the acid, the sol was still extremely opalescent. The flask was placed in a boiling water bath at 98°C. for 10 min., cooled immediately under the tap to room temperature, and the acid-insoluble fraction was centrifuged off. After a reading was made in a 2-dm. tube, the sol was replaced in the flask and again heated for 10 min. at 98°C. The procedure was repeated until a constant reading was obtained. The results are given in Table VI.

Table VI. Change in Optical Rotation of a Guar Dispersion Upon Hydrolysis with 2.5% Hydrochloric Acid

Time of hydrolysis, min.	$[\alpha]_D^{30°}$
10	+56.3°
20	+47.8°
35	+39.4°
50	+39.8°
65	+39.6°

The equilibrium value was +39.6°. This is in good agreement with the calculated value of +39.2° based on the experimentally determined mannose and galactose contents of the gum.

Uronic Acids Determination

Employing Institute method 25, six uronic acid determinations were run on the mucilage. As a "blank" for the determination, the procedure was followed with a mixture of pure mannose and galactose (Pfanstiehl Chemical Co.) in the ratio 1.6:1.

The average of the determinations on the mucilage was 0.88% carbon dioxide and the average of six determinations on the pure sugars was 0.71% carbon dioxide.

Using the value (0.71%) obtained from the sugars as a "blank," 0.17% carbon dioxide or 0.68% uronic anhydride was present in the mucilage. However, Hirst (*16*) has pointed out that yields up to 1% carbon dioxide from polysaccharides may be unreliable as an index of the presence of uronic anhydride.

In view of the results obtained and considering the limits of accuracy of the uronic acids determination, the presence of uronic anhydride in the gum is rather doubtful.

Determination of Reducing Value

The method of Farley and Hixon (*17*) was applied successfully to the determination of the reducing value of mannogalactans by Yirak (*14*) and Swanson (*18*). It was necessary, however, to modify the procedure of adding the reagents directly to the dry mucilage. The procedure employed was to add the mucilage in the form of a dispersion in which the concentration was accurately known. The reducing value was found to be 15.2 mg. Cu per gram of mucilage.

Rate of Hydrolysis

In order to analyze for mannose and galactose, it was necessary to hydrolyze the gum completely into the two component sugars. The rate of hydrolysis was determined by measuring the amount of reducing sugars obtained on hydrolysis with 2.0% sulphuric acid at 98°C. by the Munson-Walker technique (*19*). The hydrolysis was considered complete when the reducing value, as measured by the weight of cuprous oxide, reached a constant figure. Six hours of heating were required to completely hydrolyze the gum.

A small fraction of acid-insoluble material separated on treatment with the hot acid. This material was removed by filtration from each sample prior to analysis.

Galactose Determination

An improved method for the determination of galactose over the older mucic acid method has been reported by Wise and Appling (*8*). They employed a differential fermentation method with two yeasts, *Saccharomyces carlsbergensis* (N.R.R.L. No. 379) which ferments galactose and *S. bayanus* (N.R.R.L. No. 966) which does not ferment galactose. Both yeasts ferment mannose and the other common hexose sugars.

Samples were prepared by hydrolyzing the gum with 2.0% sulphuric acid at 98°C. for 6 hr. After the hydrolysis period, the samples were neutralized and made up to definite volume. Duplicate runs were made on aliquots taken from each sample and the procedure as outlined in the method was followed. Conversion of the weights of cuprous oxide to milligrams of galactose was effected by using the table of Wise and McCammon (*20*). The results are given in Table VII.

Table VII. Determination of Galactose in Purified Mucilage

Sample, g.	*Sample subjected to fermentation, mg.*	*Cu_2O after fermentation with No. 966, mg.*	*Cu_2O after fermentation with No.379, mg.*	*Net Cu_2O, mg.*	*Diln. factor*	*Galactose, g.*	*Galactan (uncorrected), %*	*Galactan (corrected[b]), %*
1.7478	218.5	94.5	9.0	85.5	16	0.665	34.2	37.1
1.7478	218.5	94.3	8.0[a]	86.3	16	0.671	34.6	37.5
2.9950	299.5	131.7	13.6	118.1	20	1.152	34.7	37.6
2.9950	299.5	130.2	13.5	116.7	20	1.138	34.2	37.1
2.8459	284.6	124.7	15.6	109.1	20	1.061	33.6	36.4
2.8459	284.6	126.0	15.7	110.3	20	1.072	33.9	36.7
2.3013	230.1	92.3	2.6	89.7	20	0.970	34.1	37.0

[a] Run on a 25-ml. aliquot instead of 50 ml.
[b] Corrected for 7.2% galactose not recoverable in procedure and 0.5% acid-insoluble fraction.

Table VIII. Determination of Mannose in Purified Mucilage

Sample, g.	Mannose added, g.	Total mannose phenylhydrazone, g.	Net mannose phenylhydrazone from sample, g.	Weight mannose, g.	Mannan (uncorrected), %	Mannan (corrected[a]), %
0.8785	0.7005	1.9102	0.8594	0.5156	58.8	60.7
0.8810	0.7014	1.9487	0.8966	0.5380	61.0	62.9
0.8771	0.7189	1.9494	0.8710	0.5226	59.6	61.5
0.8730	0.7244	1.9400	0.8534	0.5120	58.7	60.6
0.8734	0.7009	1.8966	0.8452	0.5071	58.2	60.1
0.8730	0.7251	1.9511	0.8634	0.5180	59.4	61.3
0.9205	0.6998	1.9286	0.8789	1.3182	57.3	59.2

[a] Corrected for 2.6% mannose not recoverable in the procedure and the 0.5% acid-insoluble fraction.

...s a control, mixtures of pure mannose and galactose ...the ratio of 1.6:1 were treated with 2.0% sulphuric ...d for 6 hr. at the same time and then carried through ...entire procedure. The average recovery of galac... ...n ten determinations was found to be 92.8%. The ...s obtained from the gum (Table VII) were cor...ed for the 7.2% of galactose unrecoverable and the ...% acid-insoluble fraction. The average corrected ...tan content of the guar mucilage was 37.1%.

...nose Determination

...or the determination of mannose, the gum was hy...lyzed with 2.0% sulphuric acid, followed by precipi...on of mannose as the phenylhydrazone. As de...bed in the preceding section, controls with pure ...ars were run at the same time. After the acid was ...tralized with anhydrous sodium carbonate and the ...oluble fraction removed by filtration, pure mannose ...s added to each sample. Browning (*21*) has found ...t the concentration of mannose should be of the ...er of 1% for its determination as the phenylhy...zone. The solutions were then cooled for several ...rs in a refrigerator. To the cold solution 20 ml. of ...l phenylhydrazine reagent were added with stirring. ...e reagent was made up in the proportions of 3 parts ...water, 2 parts of phenylhydrazine, and 1 part of glacial ...tic acid. After standing 48 hr. in a refrigerator, as ...ch solution as possible was decanted from the pre...itate through a tared medium fritted glass crucible. ...e mannose phenylhydrazone was washed into the cru...ble with 75 ml. of cold ethanol previously saturated with ...nnose phenylhydrazone. Then successive washings ...e made with 25 ml. of cold distilled water, 25 ml. of ...anol saturated with mannose phenylhydrazone and, ...lly, with 20 ml. of cold ether. The precipitate was ...ed at 105°C. for 4 hr. and weighed. A factor of 0.6 ...s used for conversion of the weight of mannose phenyl...drazone to mannan and 0.667 for conversion to man...e. The analytical results are given in Table VIII. ...he average of 12 control determinations with a mix...e of pure mannose and galactose showed a recovery of 97.4% of the mannose. Because the amount of mannose destroyed was slightly lower than previous investigators had found, the procedure, without the acid treatment step, was tested. Three samples consisting of mixtures of pure mannose and galactose were precipitated in the manner described for the mucilage. The remaining procedure as outlined previously was followed. The average was 100.39%, which indicates that the recovery of the mannose was satisfactory and that the procedure and technique were adequate.

Applying a correction for the 2.6% mannose lost in the procedure, as well as the 0.5% acid-insoluble fraction, the average corrected mannan content of the mucilage was 60.9%.

The mannan content of the mucilage may be determined in a completely different manner by making further use of the data obtained in the galactose analysis of the mucilage and the reducing values obtained on the total hydrolyzed gum. Essentially, the mucilage is composed of mannose and galactose units. In the fermentation method, yeast organism N.R.R.L. no. 966, which is known to ferment D-glucose, mannose, and fructose, has no effect on galactose. In the specific case of the purified mucilage, no. 966 ferments only the mannose and, hence, the cuprous oxide obtained represents the galactose.

If the no. 966 cuprous oxide value of each sample in Table VII is converted to the basis of a gram of mucilage and subtracted from the total cuprous oxide obtained from a gram of the completely hydrolyzed mucilage, the difference represents the cuprous oxide equivalent of the mannose obtained in the hydrolyzed gum. These cuprous oxide values may be readily converted to mannose by the use of the tables of Wise and McCammon (*20*). The data for the differential mannan method and the values obtained by the phenylhydrazone method are given in Table IX. The weight of cuprous oxide obtained from 1 gram of gum on hydrolysis for 6 hr. is 2333 mg.

The average mannan content of the mucilage calculated according to the method described above was

...le IX. Mannan Content of Purified Mucilage Based on Differential Reducing Values Before and After Fermentation with N.R.R.L. No. 966

Sample, g.	Cu_2O after fermentation with No. 966, mg.	Diln. factor	Cu_2O after fermentation with No. 966, mg./g. gum	Net Cu_2O due to mannose, mg.	Mannose, mg./g. gum	Mannan by differential reduction, %	Mannan determined by hydrazone procedure, %
1.7478	94.5	16	866	1467	66.6	60.0	60.7
1.7478	94.3	16	865	1468	66.6	60.0	62.9
2.9950	131.7	20	880	1453	65.9	59.3	61.5
2.9950	130.2	20	872	1461	66.3	59.6	60.6
2.8459	124.7	20	876	1457	66.1	59.5	60.1
2.8459	126.0	20	885	1448	65.7	59.1	61.3
2.3013	92.3	20	801	1532	69.8	62.8	59.2

60.0%. This value becomes 61.6% when corrected for the 2.6% mannose destroyed in acid hydrolysis. This figure determined in a completely different manner compares very well with the value of 60.9% obtained by the phenylhydrazine method.

Table X. Summary of the Characterization Analyses[a]

Ash, %	0.08
Relative viscosity, 0.20%	6.14
0.75%	602
Reducing value, mg. Cu/g. gum	15.2
Mannan	
Phenylhydrazine method, %	60.9
Differential reducing value method, %	60.0
Galactan, %	37.1
Fraction insoluble in 2.00% acid, %	0.5
Nitrogen, %	0.10
$[\alpha]_D^{30}$	+56.3

[a] All values expressed on oven-dry, ash-free basis.

Summation of the mannan, galactan, and acid-insoluble fractions of the purified mucilage totals 98.5%. A summary of the characterization data is given in Table X.

DISCUSSION OF RESULTS

The initial purification study brought out several interesting observations. The ash content was reduced to a minimum in one purification and further purifications were without effect as shown in Table II. Consideration of the accuracy and precision in the nitrogen determination at the low values of the order of 0.1% indicates that the nitrogen content approaches a minimum after the first precipitation also. It is very likely that the small amounts of ash and nitrogen in the purified material are constitutionally bound as an integral part of the polymer.

Dispersion of the commercial product into water, followed by heating and stirring, ruptured the tiny mucilage cells and allowed the contents to be hydrated. These water-insoluble gum cell membranes, together with seed coat, proteinaceous material, and undispersed mucilage, were centrifuged from the dispersion. Undoubtedly, additional mucilage could have been extracted from this insoluble material but the operation would not have been sufficiently productive to merit the time required.

The two undispersed fractions from the mucilage both had high ash and nitrogen contents. The insoluble material obtained from the first centrifuging operation probably contained the major portion of the impurities but, since a rather large portion of undispersed mucilage was also present, the nitrogen and ash values were relatively low. The undispersed fraction obtained in the second centrifuging amounted to only 0.2% of the mucilage and was composed of approximately 10% protein and 2.2% ash. The nitrogen-bearing material in the commercial gum is largely composed of gum cell membranes and incompletely removed embryo.

A spectrographic analysis of the ash from the undispersed fraction showed that the qualitative composition was practically identical with that from a similar analysis made on the ash from the purified gum. It appears that the inorganic impurities are evenly distributed in the gum. The results of this analysis, when compared with those obtained by Yirak (*14*) (who studied the mucilage from the carob seed), show that the inorganic components of the gums are quite similar. The presence of strontium, lead, cadmium, potassium, silver, barium, and several trace elements was not found in the carob seed ash. Certain elements have been found to be essential for plant growth and include calcium, magnesium, iron, boron, manganese, phosphorus, potassium, and sulphur (*22*). All these essential elements were present in the guar mucilage. It is interesting to note the presence of boron among these elements, since the mucilage in aqueous solution is very sensitive to certain compounds of boron.

The average recovery of purified mucilage plus the undispersed fraction obtained in the centrifuging operation was 94.1%. The unrecovered material was evidently lost in handling and by solubility and colloidal dispersion in the alcohol.

Aqueous dispersions of the purified gum had the very high viscosities at low concentrations, which is characteristic of the mannogalactan mucilages. This hydrophilic property creates many problems and often limits the experimental possibilities in an investigation with the material. Even in the range of 1 to 2%, the sol is so extremely thick and viscous that it is thought of as a "pseudo" gel. At 0.75% concentration, the relative viscosity is 602.

It should be stated that considerable difficulty was encountered in the determination of the optical rotation of the gum. Dispersion of the gum in water produced an opalescent sol which would not pass the beam of polarized light. However, the use of *N* sodium hydroxide produced clear sols. The peptizing action of the sodium hydroxide probably causes a rupturing and disintegration of the large micelles which produce the opalescence. The specific rotation was found to be +56.5° in *N* sodium hydroxide. This compares favorably with the value of +53.6° obtained by Heyne and Whistler (*4*) in *N* sodium hydroxide for their purified guar mucilage. The equilibrium value for a completely hydrolyzed sample of guar gum was +39.6°. This is in very good agreement with the calculated value of +39.2° based on the experimentally determined mannose and galactose contents of the gum and serves as an independent check on these experimental values.

On acid hydrolysis of the mucilage, a flocculent, acid-insoluble fraction separates. Whereas Yirak (*14*) found only 0.14% present in the carob seed mucilage, this fraction amounts to 0.5% of the guar mucilage. The material is high in ash and nitrogen and is very resistant to acid treatment. Sixteen per cent of this insoluble fraction did not dissolve when treated with 72% sulphuric acid, followed by hot 4% sulphuric acid. Anderson (*9*) has postulated the presence of an aglucone group in the mucilage to account for this material. Perhaps a melanoidin formation between proteinaceous material and the sugars takes place to produce this insoluble fraction. The same acid treatment was carried out with pure mannose and galactose and no insoluble reversion products of the sugars were obtained.

The two major components of the purified gum are mannose and galactose. The galactan content was determined by a differential fermentation method with two yeasts. The one organism quantitatively ferments all the common hexose sugars, whereas the other ferments these hexoses with the exception of galactose. A large number of control samples were run with mixtures of pure mannose and galactose. Considerable varia-

[illegible] in the recovery of pure galactose was found but it [illegible] decided that all values should be included in the [illegible]verage of 92.8%. Failure to recover 100% was due [illegible]obably to loss of sugar in the hot acid treatment and [illegible] the limitation in the accuracy of the method. The [illegible]rrected galactan content of 37.1% compares favorably [illegible]th the value of 38.4% obtained by Heyne and Whistler (*4*), who used the mucic acid technique.

A series of controls with pure mannose and galactose [illegible] run in conjunction with the mannose determination [illegible] rather wide variation in results was observed. However, all values were averaged. Although previous [illegible]vestigators (*9*, *14*) have found that approximately [illegible]0% of mannose was lost in the hot acid treatment and [illegible]bsequent recovery by precipitation as the phenyl-[illegible]razone, only 2.6% was lost in these experiments. [illegible] mannose lost was probably due wholly to the hot [illegible] treatment because the recovery of mannose from a [illegible]ixture of the two sugars without the acid treatment [illegible]as found to be 100%. Perhaps the method of heating [illegible]e samples in the hydrolysis period may account for [illegible]e smaller loss of mannose. All samples were heated [illegible] placing the containers in a boiling water bath, [illegible]hereas other investigators have used direct contact [illegible]ith a hot plate.

A completely independent determination of the man-[illegible]an content of the mucilage may be made by further [illegible]se of the data obtained in the galactose determination [illegible]nd the reducing values obtained on the total hydro-[illegible]yzed gum. The mannan content of the gum, by this cal-[illegible]ulation method, is 60.0% (61.6% when corrected for [illegible]he 2.6% of mannose destroyed) and this compares very [illegible]ell with the average value of 60.9% obtained by the [illegible]henylhydrazine method. This method of calculation [illegible] applicable because only two hexose components are [illegible]resent in the gum.

Summative analyses account for 98.5% of the purified [illegible]ucilage. The inability to account for 100% of the [illegible]ucilage, according to Wise (*23*), is very likely due to [illegible]naccuracies of the experimental methods or the pres-[illegible]nce of some other component not yet known. To-[illegible]ether with Anderson (*9*), Wise (*8*) found on analysis [illegible]f several plant endosperm mucilages that applications of these methods account for 94 to 97% of the total hydrolyzates. A small amount of uronic acid material may be present but the experimental results were not sufficiently conclusive to include it in the summation.

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RECEIVED May 1, 1952.

Guar Mannogalactan Studies

II. *Effect of Certain Variables, Including Borax, on the Rate of Oxidation of the Purified Mucilage*

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In order to produce a product from guar mucilage which is suitable as tub sizing, it is necessary to degrade the polymer. One method of doing this is by hypochlorite oxidation in the presence of borax. This reaction has been studied in the presence of *tert*-butyl alcohol or Celite as a dispersion agent. Borax decreases the rate of oxidation. The partially hydrolyzed guar mucilage does not form an insoluble complex with borax in the concentration range of 6 to 8%.

ONE of the most interesting characteristics of the mannogalactan mucilages is the thick gel that forms when a borax solution is added to an aqueous dispersion or sol. This gel is dry to the touch and does not stick to glass, paper, skin, etc. If the dry mannogalactan flour is added to a borax solution, an insoluble borax-mucilage gel forms and a coarse suspension of the

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insoluble particles results. The formation of a borax-mucilage gel is known but the nature of this complex formation is not understood. The gel or suspension of gel particles can be destroyed by lowering the pH just under 7. In a pure system the gel will remain stable for long periods of time but the addition of traces of other electrolytes causes rapid syneresis.

There is but little mention made in the literature of the gel complex with borax. Hart (*1*) mentions the gel formation as a possible test for borates and boric acid and Williams (*2*) found that the reaction of locust bean gum with borax was a characteristic test for the mannogalactan. He found that the solid gel formed was liquefied by addition of acid or an excess of reagent. However, Hart failed to liquefy the gel by addition of excess borax reagent.

Swanson (*3*) has studied the relation of borax concentration to gum and the resulting mucilage hydration and solubility. The range studied was 0.17 to 3.4% borax solutions in which the guar gum was suspended. The hydration was greatest at the low concentrations of borax and decreased with increasing concentration to a constant value from 2.0 to 3.4%. Yield determinations showed a fairly constant recovery of 86% down to a concentration of 0.3% borax. Below this figure a significant amount of gum became soluble. In this study, the ratio of gum to water was held constant.

Through viscosity studies on locust bean gum (*4*), it was found that boric acid caused no increase in viscosity at low concentrations and no gel formation at high concentrations. In the low concentrations of gum, borax or sodium metaborate tended to decrease the viscosity of gum dispersions. It was postulated that the metaborate ion was essential for gel formation and that the mechanism of the complex formation was similar to that believed to be present when borax or metaborate reacts with polyhydroxy compounds such as mannitol, glycerol, and the sugars.

To the papermaker, the mannogalactans offer many advantages. On a commercial scale, the chief use of the mucilages is a beater size and many improvements in products have been effected with quantities as low as 0.25% on the weight of the fiber. Savings in power and time have been made possible by incorporation of the mucilage in place of the mechanical work done on the stock. The expression "pouring hydration from a barrel" is a result of this property. Rowland (*5*) has reported the many papermaking benefits of guar mucilage.

In addition to the use of mannogalactans as a beater size in the paper industry, they have distinct advantages as adhesives for tub sizing. Swanson (*3*) has taken advantage of the insoluble borax-mucilage gel phenomenon in converting the mannogalactans with various oxidants.

In order to produce a product from guar mucilage which is suitable as a tub-sizing adhesive, it is necessary to degrade the polymer. A patent by Swanson (*6*) covers a process for the conversion of guar mannogalactan in the presence of borax with sodium hypochlorite for this purpose. This oxidation procedure, together with the lack of fundamental studies with a purified guar mucilage, gave impetus and formed the basis of the present work. The purified guar mucilage used in these studies was prepared and characterized as described in Part I of this series.

EXPERIMENTAL PART

Several preliminary oxidations of the gum with alkaline sodium hypochlorite were carried out in dilute systems of 0.5% concentration. The effects of pH, temperature, or borax could not be studied under such dilute conditions because the rate of oxidant consumption was extremely slow.

Experiments were undertaken with the mucilage in a more concentrated system. With the aid of borax, it was possible to obtain concentrations of the insoluble borax-gum complex suspension as high as 7 to 8%. In these experiments the rate of oxidant consumption was increased.

In order to investigate the effect of borax on the rate of oxidation of the mucilage, the obvious step is to conduct experiments in which it is the only variable. However, concentrated dispersions of guar mucilage in the range of 7 to 8% cannot be obtained because of its extremely hydrophilic nature. Wetting of the mucilage by water can be delayed by mixing the dry gum with an alcohol. When this mixture, in paste form, is dropped into vigorously stirred water, it is dispersed evenly before the water penetrates through the alcohol film to the gum. *tert*-Butyl alcohol is used in this work because of its resistance to oxidation.

Since the introduction of *tert*-butyl alcohol into the oxidation system may have an effect on the equilibria involved, a study was made to determine the effect of the addition of this alcohol on the pH. It was found that the pH meter readings increased at any pH on addition of alcohol and that this effect was increased as the pH was lowered. To cancel any unknown effects, *tert*-butyl alcohol was used in parallel experiments with borax as well. In all systems with *tert*-butyl alcohol present, the term "pH" refers to pH meter readings only.

EFFECT OF *tert*-BUTYL ALCOHOL ON THE RATE OF CHLORINE CONSUMPTION

In order to determine the effect of *tert*-butyl alcohol on the rate of oxidation of the gum, the following experiments were performed. The first consisted of two identical oxidations of the mucilage with sodium hypochlorite in the presence of borax without alcohol in the system.

The procedure followed in these oxidations was as follows: The reaction vessel (a 600-ml. beaker) was placed in a constant temperature bath. After the beaker was in place and the water and borax were added, a Lightnin' stirrer fitted with a glass propeller was used to agitate the contents until the borax dissolved. The calculated amount of sodium hypochlorite was then added, followed by the gum. As the gum was being added, the Lightnin' stirrer was allowed to run at top speed to insure thorough and even mixing. After about 1 min., the pH was determined (using a type E glass electrode) and the solution was adjusted to 11 ± 0.2 with sodium hydroxide. [In this and all subsequent work the type E glass electrode was used to eliminate corrections in solutions of high pH containing sodium ions.] The pH was maintained constant by periodic addition of 30% sodium hydroxide. Samples

removed for analysis by the following technique. A coarse fritted glass crucible was fitted at the top with a rubber stopper bearing a long glass tube. By inserting the bottom of the crucible into the reaction mixture and applying suction to the glass tube a clear sample was drawn into the crucible. After a 2-ml. sample was taken, the remaining liquid was blown back

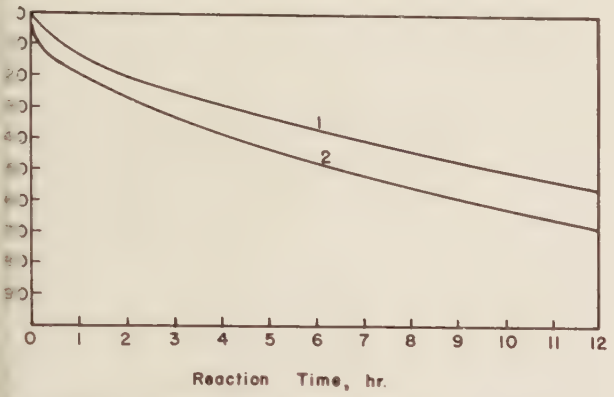

Fig. 1. Effect of tert-butyl alcohol on the rate of oxidation of pure mucilage in the presence of borax at 30° and pH 11

Experiments in absence (1) and presence (2) of alcohol.

to the beaker. The available chlorine was determined as previously described. Throughout the entire experiment the stirrer was run at a speed sufficient to insure constant mixing of the reactants. The initial concentration of chlorine was determined on a mixture of the same quantities of reagents without gum present.

Table I. Conditions Used in the Oxidations of Gum with *tert*-Butyl Alcohol Present

pH	11.0 ± 0.25
Temperature, °C.	30 ± 1
Gum, g. (oven-dry)	25.0
Chlorine, g.	10.0
Equivalents of Cl_2/anhydrohexose unit	1.82
Volume NaOCl, ml.	55.4
Volume H_2O, ml.	210
Volume *tert*-butyl alcohol, ml.[a]	50
Gum concn., % (by weight)	7.25
Borax, g.	10.0

[a] Alcohol replaced by water in Experiments 1 and 2.

The conditions used in these oxidations are given in Table I and the results are given in Table II.

Table II. Rate of Chlorine Consumption in the Oxidation

Experiment 1			Experiment 2		
Time, hr.	*Chlorine concn., g./l.*	*Chlorine consumed, %*	*Time, hr.*	*Chlorine concn., g./l.*	*Chlorine consumed, %*
0	32.7	0	0	33.0	0
0.2	30.9	5.5	0.25	31.3	5.2
0.7	29.1	11.0	0.75	28.8	12.7
1.6	26.7	18.4	1.5	27.2	17.6
3.6	23.8	27.2	3.5	24.0	27.2
6.8	19.8	39.5	6.5	20.2	38.9
9.5	16.8	48.7	9.5	17.2	48.0
12.0	14.2	56.6	10.25	16.4	50.4

The second experiment consisted of an oxidation in the presence of *tert*-butyl alcohol at a pH meter reading of 11. The conditions followed are given in Table I. The experimental procedure just described was followed in this oxidation. The borax-gum complex formed in the same manner as in the absence of alcohol. The data obtained are presented in Table III. These data and those of Table II are plotted in Fig. 1.

Blank runs were carried out with no mucilage present with and without alcohol and over the 12-hr. reaction period there was no loss of available chlorine.

EFFECT OF pH IN THE PRESENCE OF *tert*-BUTYL ALCOHOL WITH AND WITHOUT BORAX

The results of the previous study concerning the effect of *tert*-butyl alcohol on the rate of oxidation of the gum emphasized the need of using the same quantity of alcohol in all oxidations. In this study of the effect of pH on the rate of oxidation, two experiments were carried out at each pH meter reading. One was conducted in the presence of borax in which the gum existed as the borax-gum complex and the other experiment was carried out in the absence of borax. In the latter case the gum was in dispersion during the reaction. All experiments were conducted in the constant temperature bath at 30°C. The conditions given in Table I were followed. Blank runs were made for each individual experiment.

The procedure used in the oxidations with borax present has been described. In those experiments where borax was not present, the following procedure was used: The water and sodium hypochlorite were added to the beaker and mixed. With stirring, *tert*-butyl alcohol was added to the gum in a 250-ml. beaker. A uniformly wet paste was obtained, which was dropped into the beaker accompanied with vigorous stirring. For the first few minutes, the dispersion was a stiff mass. However, the viscosity decreased very rapidly, and efficient agitation was then possible. From this point the procedures were identical.

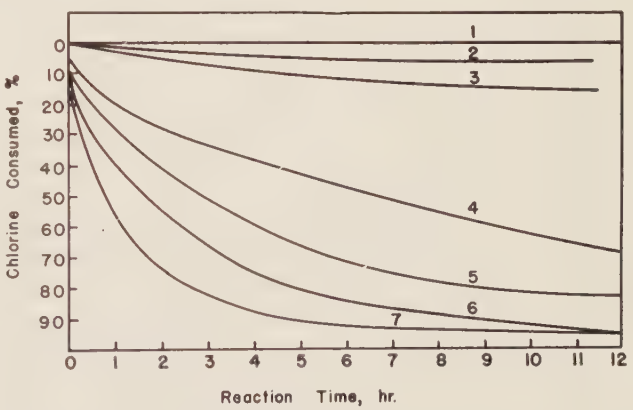

Fig. 2. Effect of pH on the rate of oxidation of pure mucilage in the presence of tert-butyl alcohol with and without borax at 30°

Blank with and without borax at pH 11 (1), at pH 10 (2), and with borax at pH 10 (3). Mucilage with borax at pH 11 (4) and pH 10 (5). Mucilage at pH 11 (6) and pH 10 (7).

The results of the blank and mucilage oxidation experiments are shown in Fig. 2.

At pH meter reading 11, there was no loss of available chlorine in the blank experiments within the 12-hr. reaction period. However, at pH 10 there was a gradual loss of oxidant during this period.

The blank curves (Fig. 2) do not follow any definite order of reaction. The rate of consumption was not proportional to the concentration of chlorine present and, without this correlation, the curves were practically useless for accurately correcting the gum oxidation rate curves. It is obvious that, when gum was present in the system, the loss of chlorine would be much less than the blank runs indicated because the concentration of oxidant constantly decreased. Therefore, because the blanks were relatively small, the pH 10 curves were arbitrarily corrected for one half the loss shown by the blank runs.

EFFECT OF TEMPERATURE IN THE PRESENCE OF *tert*-BUTYL ALCOHOL WITH AND WITHOUT BORAX

In this series of experiments, the procedures described in the previous sections and outlined in Table I were followed. A series of experiments, conducted at pH meter reading 11 were run at two temperatures, 30

Table III. Rate of Chlorine Consumption in the Oxidation of Purified Guar in the Presence of Borax and *tert*-Butyl Alcohol at 30° and pH 11

Time, hr.	*Chlorine concentration, g./l.*	*Chlorine consumed, %*
0	33.0	0
0.25	28.8	12.6
0.50	27.8	15.6
1.5	25.2	23.5
3.5	21.0	36.3
6.9	15.8	52.0
9.9	12.3	62.7
12.0	10.3	68.8

and 40°C. As was the case at 30°, the blank runs made at 40° showed no loss of available chlorine over the 12-hr. period.

The results of the temperature study are shown in Fig. 3.

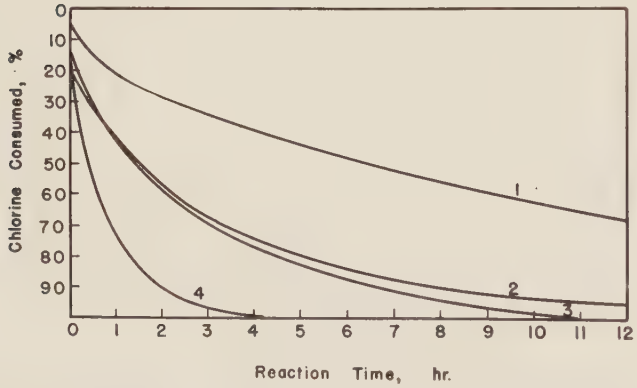

Fig. 3. Effect of temperature on the rate of oxidation of pure mucilage in the presence of tert-butyl alcohol with and without borax at pH 11

With (1) and without borax (2) at 30°. With (3) and without borax (4) at 40°.

A similar series of experiments was carried out at pH 10 with temperatures of 20, 30, and 40°C. The trends indicated in Fig. 3 were found to take place.

DEVELOPMENT OF THE "CELITE" METHOD

In view of the fact that objections may be raised to the conclusions drawn from the previous work because of the presence of *tert*-butyl alcohol, the use of Celite (diatomaceous earth or pure silicon dioxide) as an expedient in making concentrated dispersions of the gum was investigated.

The experimental procedure developed was very similar to the alcohol method. The Celite and dry

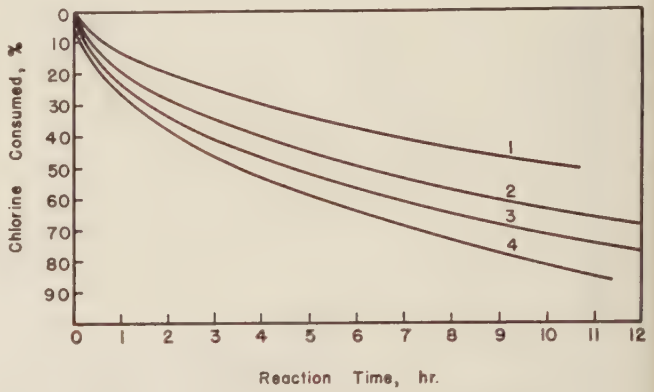

Fig. 4. Effect of pH on the rate of oxidation of pure mucilage at 30°

With borax at pH 11 (1) and pH 10 (2). With celite at pH 11 (3) and pH 10 (4).

gum were thoroughly mixed on a large sheet of glazed paper and this mixture was rapidly added to the beaker containing water and hypochlorite, accompanied with vigorous agitation. A very thick mass resulted, which resembled a highly concentrated clay slip. However, after about 5 min. as the viscosity decreased, efficient circulation was obtained. Samples were taken in the manner described for the borax system and the pH was maintained constant by addition of sodium hydroxide. In this case, the pH meter readings represented the true pH of the system.

The experimental conditions followed in the Celite-gum oxidations were the same as those presented in Table I except that, in place of the borax, 25.0 grams of Celite were used. Blank runs showed no loss of chlorine.

Two oxidations were made at 30°, one at pH 10 and the other at pH 11. The data obtained from these experiments are presented in Fig. 4.

EFFECT OF IMPURITIES IN COMMERCIAL GUAR

In order to determine what effect the impurities present in the commercial gum have on the rate of oxidation, the following experiment was carried out. In the purification of the mucilage, an undispersed fraction was obtained. The nitrogen content of the material was 0.77%. This material was oxidized in the presence of borax at 30°C. and at pH 10 in the same manner as described for the mucilage. An insoluble complex with the borax formed in the usual manner. During the initial stages of the reaction, there was a great deal of foaming because of liberated gas. This foaming was never observed in the oxidations of the purified gum. The rate curve is compared with that of the pure gum in Fig. 5.

STUDIES WITH PARTIALLY DEGRADED MUCILAGE

In all the experiments made in the presence of borax,

e mucilage was present as an insoluble complex. It s thought that additional light would be thrown on e problem if a partially degraded guar product could produced which no longer formed an insoluble com- ex with borax in the concentration range of 6 to 8%. ries of acid-hydrolyzed products was prepared to termine the length of time necessary to degrade the

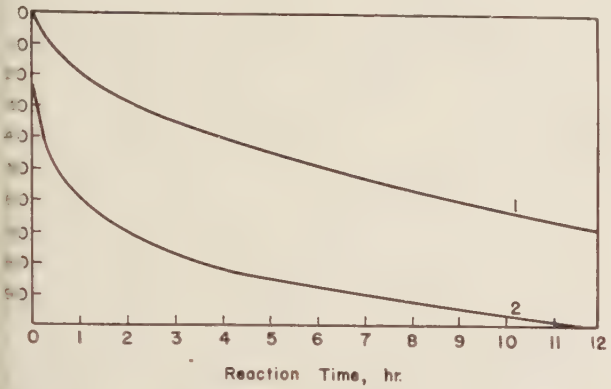

Fig. 5. Effect of impurities in commercial mucilage on the rate of oxidation at 30° and pH 10

Purified mucilage with borax (1). Undispersed fraction from first centrifuging of the mucilage in the purification procedure

ucilage to the point at which an insoluble complex no nger could be formed.

The procedure was as follows: Fifteen grams oven- y gum were mixed with 375 ml. of 2.00% sulphuric id in a 500-ml. Erlenmeyer flask. The flask was ted with an air condenser and placed in a large boil- g water bath. During the hydrolysis period, the ntents of the flask were agitated from time to time. the end of the heating period, the flasks were cooled pidly to room temperature and the acid was neutra- ed with sodium hydroxide. After the acid-insoluble ction was centrifuged off, the clear sol was electro- alyzed. The product was recovered by precipitation the dialyzed sol into four volumes of acetone.

It was found that a 40-min. hydrolysis period was fficient to produce a satisfactory product. The n content was 0.25% and the reducing value was 290 g. Cu/g.

ble IV. Conditions Used in the Oxidation of the 40-Min. Acid-Hydrolyzed Product

pH	10.0 ± 0.3
Temperature, °C.	30 ± 1
Hydrolyzed product, g. (oven-dry)	10.0
Chlorine, g.	4.0
Equivalents of Cl_2/anhydrohexose unit	1.82
Volume NaOCl, ml. (30 g.)	24.1
Volume H_2O, ml.	127
Product concn., % (by weight)	6.0
Borax, g.	4.0

Oxidations of the hydrolyzed product were made in e presence and absence of borax. The conditions llowed are presented in Table IV. Consumption of ailable chlorine was followed in the two experiments d the data are plotted in Fig. 6. In the oxidation of e degraded product with borax present, no insoluble mplex formed.

DISCUSSION OF RESULTS

When a borax solution is added to an aqueous dispersion of the mucilage, a solid irreversible gel forms. However, if the dry mucilage is added slowly to a borax solution, a coarse suspension of the borax-gum complex is formed and the hydrophylic nature of the mucilage is lost. The use of borax thus provides a convenient means of obtaining concentrations of the mucilage as high as 7 to 8%.

It was desirable to produce concentrated dispersions of the mucilage for oxidation studies. When a "clump" of mucilage is dropped into water, that on the outside immediately becomes hydrated and swollen and prevents the material within from being dispersed. It is possible to cover all of the dry mucilage particles with a film of *tert*-butyl alcohol since the gum does not swell as in water. Introduction of this alcohol-wet gum into vigorously stirred water produces a smooth dispersion. The water probably follows the film of alcohol and is evenly spread throughout the gum before it becomes hydrated. This alcohol technique provides a means of producing concentrated dispersions of the mucilage in the absence of borax.

tert-Butyl alcohol was used in many experiments to facilitate the preparation of concentrated dispersions of the mucilage. Results indicated that the presence of *tert*-butyl alcohol in the oxidation system disturbed

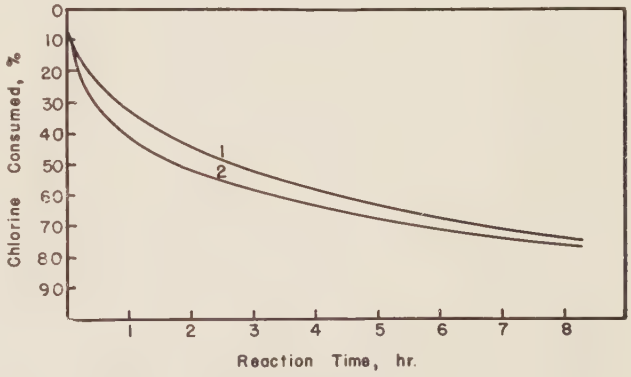

Fig. 6. Effect of borax on the rate of oxidation of a 40-min. acid-hydrolyzed product

Borax present (1). Borax absent (2).

the equilibria involved. The addition of a nonaqueous component to an aqueous system changes the activity of the water. Inasmuch as the reference solution inside the glass of a glass electrode is an aqueous solution in which the activity of the water is approximately 1.0, the glass electrode is in error when used to measure the pH of a system containing *tert*-butyl alcohol. It was shown that the introduction of the alcohol causes the pH meter readings to increase at any pH and that this effect is increased as the pH is lowered.

At a pH meter reading of 11, *tert*-butyl alcohol does not consume oxidant over a period of 12 hr. However, as the pH is lowered to 10, there is a loss of chlorine in blank runs. The loss is more rapid when borax is present in the system. The equilibrium of the oxidant may be thrown more and more toward the less stable hypochlorous acid phase as the pH is lowered and this may account for the gradual loss of chlorine. Why the loss should be greater in the presence of borax is not known. It was shown that borax had no effect on the

oxidation potential of the *tert*-butyl alcohol-sodium hypochlorite system. In a neutral or alkaline medium, tertiary alcohols are definitely resistant to oxidation but the possibility of chlorine substitution exists.

tert-Butyl alcohol in the presence of borax increased the rate of oxidation of mucilage at a pH meter reading of 11, as shown in Fig. 1. This action supports the evidence found that apparently the pH of the system with alcohol present was lower than the meter reading indicated. Whether the alcohol increased the rate of chlorine consumption by actually lowering the pH of the system by approximately one unit, by affecting the equilibrium of the oxidant to produce more reactive hypochlorous acid, or by catalyzing the reaction in some way is not known.

By means of the *tert*-butyl alcohol method it is possible to study the effect of pH and temperature on the oxidation of guar mucilage in the presence and absence of borax. The rate of oxidation, in both systems, is increased as the pH is lowered (Fig. 2). This may be explained by the shift in the equilibrium of the oxidant. The system $Cl_2 = HOCl \leftrightharpoons OCl^-$ is very sensitive to pH. In the alkaline range the system equilibrates between $HOCl \leftrightharpoons OCl^-$ only. Hypochlorous acid has a higher oxidation potential than OCl^- at unit activity. As the pH of a hypochlorite solution is decreased, the oxidation potential increases probably because the ratio of hypochlorous acid to hypochlorite ion becomes greater. The rate of oxidation, therefore, would be expected to increase as the pH is lowered.

Reference to Fig. 3 shows that a 10° rise in temperature has the effect of roughly doubling the rate of oxidation of the mucilage, both in the presence and absence of borax. This phenomenon is common to many chemical reactions.

Under all conditions studied, the introduction of borax into the system caused the mucilage to be oxidized more slowly than in the corresponding experiment conducted under the same conditions without borax. In the presence of borax, the mucilage system was made up of discrete insoluble particles. The slower rate shown by the curves may have been due to the time required for the oxidant to diffuse into the particles. However, the difference in rate of oxidation may have been due to the protective action of borax. Although the nature of the combination of borax or metaborate ion with the gum is not known at the present time, it may be of a chemical nature and, as such, may have resisted oxidation. As a result of this chemical combination between the gum and borax, the nature of the reaction between the mucilage and the oxidant may have been markedly different from that taking place in the absence of borax. A third possibility was that both phenomena were involved.

The use of Celite provided another method of obtaining concentrated dispersions of the gum. Oxidations of the mucilage were made in a Celite system (Fig. 4). It is evident from the curves that the mucilage in the Celite system was oxidized more rapidly than in the borax system. It is possible, however, that the Celite acted as a catalyst, since it possesses a very large surface area. Chemically, though, the pure silicon dioxide would be inert. The effect of borax in this study was the same as that observed in the alcohol system. This same phenomenon was found in spite of the fact that an entirely different type of system was involved in which the material used to facilitate the dispersion of the gum was a chemically inert solid.

The marked differences in the rates of oxidation of the mucilage in the presence and absence of borax suggested the possibility that the mechanism of the reactions was different. A study of the data was made to determine the order of the reactions. A zero-order reaction was approximated by the oxidations made in the presence of borax after the reaction had proceeded for several hours. In this type of reaction the velocity is unaffected by concentration or time, and

$$-dc/dt = k$$

where

c = concentration
t = time
k = a constant

The data were not conclusive and the value of k varied from 0.004 to 0.020. Data from the oxidations made in the absence of borax did not fit any order of reaction.

The gas evolved in the oxidation of the undispersed fraction of the commercial gum was very likely nitrogen. Swanson (*3*) noted this evolution of gas in the oxidation of commercial guar with sodium hypochlorite in the presence of borax and determined that it was nitrogen.

The rapid initial consumption of oxidant in the oxidation of the undispersed fraction in Fig. 5 may explain in part the similar trend shown in the oxidation of the purified mucilage. After the first 2 hr. reaction, the purified mucilage consumed on the average 4% of oxidant per hour. In the first half hour, the undispersed fraction consumed 52% of oxidant. Subtracting the 2% of oxidant which was consumed by the gum itself in this half-hour period, 50% of oxidant was expended on the impurities. Assuming that the major portion of the oxidant was expended on proteinaceous material, an initial drop of 7% in the curve for the oxidation of the purified mucilage which has a nitrogen content of 0.10% may be calculated. The value found by experiment was about 14%. It is clear from the comparison of these curves that, in any work of a fundamental nature, it is necessary to use a highly purified gum in which the proteinaceous material and other impurities are at a minimum.

Degradation of the molecule through partial hydrolysis produces a mucilage product which no longer forms an insoluble complex with borax. Both in the presence and absence of borax, studies with this product showed that borax decreased the rate of oxidation. The difference in the rate of oxidation, though not as great as that noted with pure mucilage, was probably that due solely to a complex formation of the borax with the mucilage.

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Guar Mannogalactan Studies

III. *Characterization of the Oxidized and Hydrolyzed Mucilage*

ARTHUR J. HAUG

The oxidation of guar mannogalactan by alkaline sodium hypochlorite produces a product having a molecular weight lower than the original as evidenced by a decrease in solution viscosity and an increase in reducing power. A part of the sugar residues was oxidized to uronic anhydride. The component sugars which could be determined by analysis were reduced in amount. The content of mannose was reduced to a greater extent than that of the galactose in the oxidation. In the presence of borax, the rate of oxidation is decreased to approximately one half of that with borax absent. Part of this decrease is due to the presence of the mucilage in an insoluble borax-mucilage gel as discrete particles so that the reaction is heterogeneous and topochemical in nature.

THE first paper in this series concerned the purification and characterization of the mucilage. A purified fraction of the mannogalactans from commercial guar mucilage was prepared by a specially developed hot water extraction and centrifuging technique. This fraction amounted to 76% of the original mucilage.

The effect of borax, pH, temperature, and impurities on the rate of oxidation of the purified mucilage with sodium hypochlorite in alkaline condition was discussed in Part II of this series.

To supplement the studies made on the kinetics of the oxidation of guar mucilage, a series of oxidations was made in which the converted products were isolated and purified. These products were characterized by various analytical determinations and from the data the effect of borax on the nature of the reaction was determined.

The methods employed in the oxidations have been described in Part II of this series. One sample was prepared by oxidation of the mucilage in a dilute system. Conversion of two other samples was made in concentrated systems, both in the presence of borax. Finally, in order to obtain additional information concerning the effect of borax on the oxidation of the mucilage, two oxidations were made using the *tert*-butyl alcohol method (described in Part II). In this study, one oxidation was made in the presence of borax and the other in the absence of borax.

PURIFICATION OF PRODUCTS

The oxidized gum products contain inorganic impurities in varying amounts. It was desirable to purify the products to insure accuracy in the analytical determinations. In the cases of the products containing borax, it would be practically impossible to determine the ash content accurately and unknown factors would be introduced into all subsequent analyses, especially in the galactose determination employing yeasts. Electrodialysis in a three-compartment cell was used to purify all products. On completion of the dialysis, the material was precipitated from the dispersion by acetone and dehydrated several times with fresh acetone.

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PRELIMINARY OXIDATIONS AND RESULTS

Three initial experiments were made to obtain converted products for analytical study. The conditions followed in these oxidations are summarized in Table I.

Table I. Conditions Used in the Oxidation of Guar Mucilage for Analysis

	Experiment		
	D	*E*	*F*
pH (meter reading)	11.0 ± 0.3	11.0 ± 0.5	11.0 ± 0.2
Temperature, °C.	25 ± 2	27 ± 2	29 ± 2
Gum, g. (oven-dry)	50	50	50
Chlorine, g.	20	20	20
Equivalents of Cl_2/anhydrohexose unit	1.82	1.82	1.82
Volume NaOCl, ml.	134	154	155
Volume H_2O, ml.	12,280	378	378
Gum concentration, % (by weight)	0.40	8.0	8.0
Borax, g.	0	47.6	25.0
Reaction time, hr.	12	12	12

On completion of experiment D, the reaction mixture was poured into 31 liters of acetone with stirring. The precipitated gum was filtered on a cloth and placed in fresh acetone. The usual dehydration procedure was then followed. The oxidized product was purified by electrodialysis. About 7% of the available chlorine was consumed in the experiment.

The procedures followed in experiments E and F were identical. After the 12-hr. reaction period, the fractions insoluble in the reaction medium were filtered on large fritted glass crucibles, washed with a 1.5% borax solution, and purified by electrodialysis. The filtrates from each oxidation were purified by electrodialysis followed by precipitation of the fractions soluble in the reaction medium (E-1 and F-1) and insoluble in acetone (E-2 and F-2). An accident prevented use of E-2 for analysis.

Characterization of the purified products followed the procedures described for the mucilage in Part I of this series. A summary of all the characterization determinations made on the converted products is presented in Table II. For purposes of comparison, data obtained in the characterization of the pure mucilage are included.

OXIDATIONS IN THE PRESENCE OF *tert*-BUTYL ALCOHOL WITH AND WITHOUT BORAX

Further information on the effect of borax in the oxidation of guar mucilage was obtained by oxidation in the presence of *tert*-butyl alcohol. No difficulty was ex-

Table II. Summary of the Characterization Determinations Made on the Pure Mucilage and Products of Oxidation

Determination[a]	*Pure gum*	*D-1*	*E-1*	*F-1*	*F-2*
Yield, %	....	89	77	68	15
Ash, %	0.08	0.48	0.53	2.40	10.46
Relative viscosity, 0.500% concn.	6.14[b]	2.22	1.13	1.09	.....
Reducing value, mg. Cu/g. product	15.2	28.6	150.3	106.3	180.5
Uronic acids, % uronic anhydride	3.52[c]	4.00[c]	7.46[c]	8.70[c]	12.82[c]
Mannan, phenylhydrazine method, %	60.9	59.4	43.4	43.8	38.4
Differential reducing value method, %	60.0	57.8	51.0	48.5	44.1
Galactan, %	37.1	38.0	34.4	32.4	28.7
Fraction insoluble in 2% acid, %	0.5	0.6	0.4	0.5	0.05

[a] All values expressed on oven-dry, ash-free basis.
[b] Run at 0.202% concentration.
[c] Results high. Mixture of pure mannose and galactose gave 0.71% carbon dioxide, equivalent to 2.84% uronic anhydride.

perienced in the purification of the converted products. The conditions used are given in Table III.

The experimental procedure used in these oxidations was the same as that outlined in the rate of oxidation studies in Part II. Both reactions were allowed to proceed to exhaustion of the oxidant.

Table III. Conditions Used in the Oxidation of Purified Guar Mucilage in the Presence of *tert*-Butyl Alcohol for Analysis

pH (meter reading)	11.0 ± 0.2
Temperature, °C.	40 ± 1
Gum, g. (oven-dry)	50.0
Chlorine, g.	20.0
Volume NaOCl, ml. (147 g.)	116
Volume H_2O, ml.	414
Volume *tert*-butyl alcohol, ml. (79 g.)	100
Gum concentration, % (by weight)	7.25
Borax, g.[a]	20.0

[a] Borax was used in oxidation G only.

In the case of experiment G, conducted in the presence of borax, two products were obtained. The fraction insoluble in the reaction medium (G-1) was filtered and electrodialyzed. The second product (G-2) was obtained from the filtrate and was the fraction of converted mucilage that was soluble in the reaction medium and insoluble in acetone. The filtrate was electrodialyzed and the product precipitated by means of acetone.

After the hypochlorite was exhausted in oxidation H (in the absence of borax), the contents of the reaction beaker were transferred to the dialysis apparatus for purification. The purified product was precipitated with four volumes of acetone.

Table IV. Summary of the Characterization Analyses Made on the Pure Mucilage and Products G-1 and H-1

Determination[a]	*Pure gum*	*G-1*	*G-2*	*H-1*
Yield, %	....	79	2.4	76
Ash, %	0.08	1.46	19.69	1.09
Relative viscosity, 0.50% concn.	6.14[b]	1.08	.....	1.07
1.00% concn.	....	1.18	.....	1.13
1.50% concn.	....	1.27	.....	1.22
Reducing value, mg. Cu/g. product	15.2	186	290	97
Uronic acids, % uronic anhydride	3.52[c]	10.62[c]	15.08[c]	11.36[c]
Mannan, phenylhydrazine method, %	60.9	34.4	.....	46.2
Differential reducing value, method, %	60.0	46.0	.....	49.9
Galactan, %	37.1	32.9	.....	32.7
Fraction insoluble in 2% acid, %	0.5	0.3	.....	0.5

[a] All values expressed on oven-dry, ash-free basis.
[b] Run at 0.2% concentration.
[c] Results high. Mixture of pure mannose and galactose gave 0.71% carbon dioxide, equivalent to 2.84% uronic anhydride.

The products were analyzed by the methods discussed in Part II of this series. Because of the small yield, only a few analyses could be performed on product G-2. A summary of the analyses is given in Table IV.

PARTIALLY HYDROLYZED MUCILAGE

In the manner described in Part II, three products, partially hydrolyzed with 2.00% sulphuric acid, were prepared. The data obtained in the characterization of these products are given in Table V.

Table V. Characterization of Partially Hydrolyzed Mucilages

Time of hydrolysis, min.	15	30	37
Yield,[a] %	91.7	77.4	75.0
Ash, %	4.12	1.32	3.78
Reducing value,[a] mg. Cu/g.	75	236	357
Mannan,[a] %	56.8	58.1	59.7
Galactan,[a] %	37.3	33.6	30.3

[a] Values expressed on oven-dry, ash-free basis.

DISCUSSION OF RESULTS

Analyses were made on a purified product obtained by oxidation in a dilute system. Under the conditions employed, little chemical change in the mucilage was effected. The yield was similar to that obtained when the pure mucilage without any oxidation treatment is carried through the purification procedure. The most noticeable chemical effect was the decrease in chain length of the molecule, as indicated by the relative viscosity measurements. Reducing value and uronic acids increased only a small amount as compared with the gum, and the mannan and galactan contents were practically unchanged. The mannan content calculated by the differential reducing method compared favorably with the value obtained by the phenylhydrazine method. It appears that the mucilage underwent a "hydrolysis" in this reaction and very little more.

However, the products oxidized in the presence of borax were substantially degraded. All the determinations indicated marked chemical alteration or degradation. The variable in experiments E and F is the quantity of borax. When the amount of borax is decreased, the yield of the fraction insoluble in the reaction medium is lowered. Product F-1, oxidized in the presence of the smaller amount of borax, showed the greatest degradation. In addition to the poorer yield, the uronic acids content was higher and the galactan content slightly lower. It is interesting to note that the reducing value of F-1 was only 106 as compared with 150 mg. Cu per gram for E-1. Perhaps those groups which had a reducing value in E-1 were either destroyed or converted to carboxyl groups in F-1. The fraction soluble in the reaction medium and insoluble in acetone, as would be expected, was degraded most strongly.

A discrepancy in the two methods of mannan deter-

ation was observed with the products converted in presence of borax. In each case, the mannan de- ined by the phenylhydrazine procedure was ap- ximately 6% lower than that calculated from the re- g values. It is probable that the mannose res- , which amount to this 6% difference, are slightly ed structurally so that they are no longer recover- as the insoluble phenylhydrazone. However, the st organism no. 966 still may ferment these altered tures in the same manner as it ferments the man- e units.

periments G and H provided two products which consumed equal quantities of oxidant. One prod- G-1) was oxidized in a heterogeneous state be- of the formation of the insoluble borax-gum com- whereas H-1 was in dispersion throughout the on. The analytical results from these products ded a means of studying the reactions and be- r of the guar polymer in these two systems. Ex- for the reducing values and mannan contents, the products were quite similar. The same discrep- in the determination of the mannan contents by two methods was found with product G-1 but not H-1. The presence of borax in some way causes alteration of the mannose residues so that they are determinable by the phenylhydrazine procedure. e marked difference in reducing value may be ex- ined on the basis of the physical nature of the two tems. The distribution of chain lengths obtained m a heterogeneous system, such as was in evidence the presence of borax, will be heterogeneous, whereas ormal distribution will result from the homogeneous tem. This difference in distribution could account the difference in reducing values. It should be nted out that the time of reaction varied greatly in two experiments. The time required for product 1 to consume the oxidant was exactly double that re- ired by H-1.

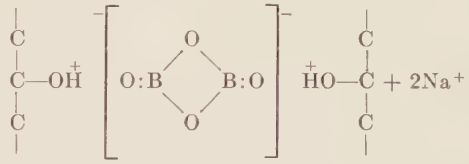
It was found that partial hydrolysis of the gum with % acid to a relatively low reducing value removes the actose units to a greater extent than it does the man- se units. The data indicate that, when the gum s hydrolyzed to give a value of 15% of the total re- cing value of the completely hydrolyzed gum, the nnan content remained virtually unchanged but a rked loss of galactan had occurred. Evidently, the acial configuration of the guar molecule makes the actose units more accessible to attack by the hydrol- s.

Aqueous dispersions of the mucilage at low concen- tions are characterized by extremely high viscosities. e side chain galactose units, each with four hydroxyl ups, afford excellent opportunities for hydrogen nding. The hydrogen can act on the strong elec- negative oxygen atoms directly or through the me- m of water. The high viscosity is a manifestation the interlocking and hydrogen bonding of the hy- oxyl groups on the galactose units. As the concen- tion of the sol is increased, the structure becomes re closely packed and the viscosity increases enor- usly.

The extremely hydrophilic nature of the guar man- galactan is inherent in the material itself. However, e easily available side chains of galactose may par- lly explain this property.

Characteristic of the mucilage is the solid, irreversible gel that forms on addition of a borax solution. The water binding ability of this gel is enormous; a solid gel will form with only 0.5% mucilage. The galactose units on adjacent chains in this case are bound together by means of a complex union with borax or metaborate ion. Where, before, the hydrogen bond formed the basis of the union, the complex may be thought of as "cementing" the units together to give the gel cohesive strength. The mucilage then simulates a honeycomb or brush heap structure and the water is entrapped in the voids between the galactose units and the mannan chains. In this manner, a small amount of mucilage may immobilize a large quantity of water.

The gel formation is possible only in alkaline systems and when the pH is lowered below 7, the gel phase disappears. Furthermore, evidence has been offered that the metaborate ion is the active one in complex formation involving nonionizable polyhydroxy compounds and that the complex formation is based upon the reaction between molecule and ion and not between molecules or between ions. It would appear, therefore, that boric acid is not the important inorganic component in the gel formation. It is postulated that the metaborate ion is the active component, and the following tentative interpretation of the structure is given:



The metaborate may exist as a monomeric or trimeric ion but the general picture shown above is not changed in either case.

The hydroxyl groups of the mucilage are definitely involved in the borax complex formation because methylated guar mucilage will not form an insoluble complex.

Products G-1 and H-1 had practically the same galactan content. However, the mannan content of G-1 was considerably lower than that of H-1 (12%) by the phenylhydrazine procedure; by the differential reducing method the mannan contents were similar. It would thus appear that both the hydrogen bonding and metaborate unions were sufficiently strong to divert the main attack from the galactose residues to the unprotected mannose residues. The greater loss of mannan in the case of the borax system is understandable when the time of reaction is considered. (The oxidation of mucilage in the presence of borax required twice the time required when the reaction was carried out in the absence of borax.) Throughout the reaction period the oxidant concentration was at a higher level than was the case in the other system. Therefore, more severe attack on the mannan was possible. The discrepancy observed when the mannan content of G-1 is determined by the phenylhydrazine method and the differential reducing value method indicates that the chemical degradation of the 12% mannan may not be too extensive.

The uronic anhydride contents and relative viscosities of G-1 and H-1 indicate similarity of the products.

One further apparent discrepancy is the reducing values of G-1 and H-1. The heterogeneity of the system oxidized with borax present probably accounts for this marked difference. In the case of oxidation of cellulose in the fibrous form, a topochemical reaction takes place and the chains on the outside of the fiber are strongly degraded, whereas those near the center of the fiber are degraded very little. Probably a similar phenomenon took place in the borax system and a heterogeneous distribution of chains resulted. Also, the chemical alteration resulting in the 12% reduction of mannan units mentioned above may be such that additional reducing groups are present in this case.

Acid hydrolysis of the mucilage removes the galactose units with concomitant loss in viscosity and gel-forming ability. The mannan content of the partially acid hydrolyzed mucilage remained virtually constant, indicating that the basic mannan chains were unattacked. The alkaline oxidation also degraded the polymer to a marked degree as measured by relative viscosity but the gum still existed in the form of the insoluble borax-gum gel at the condition of the reaction.

On the basis of the experimental results and their interpretation in the light of the proposed structure of the guar molecule, it is postulated that the presence of borax in the alkaline hypochlorite oxidation reaction does not alter the mechanism of the reaction but creates a hindrance or block which extends the reaction time.

Received May 1, 1952.

Guar Mannogalactan Studies

IV. Conversion of Purified Mucilage for Tub-Size Adhesive

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Conversions of the purified guar mucilage by oxidation in the presence of borax with sodium hydroxide at pH 11 produce adhesives which are useful as tub-sizing materials. Only a small amount of oxidant (approximately 5%) is necessary to degrade the guar polymer to produce a product of suitable viscosity. The folding endurance and bursting strength of a rag sheet were increased up to 187 and 46%, respectively.

To the papermaker the mannogalactans offer many advantages. On a commercial scale, the chief use of the mucilages or gums* is as a beater size and many improvements in products have been effected with quantities as low as 0.25% on the weight of the fiber. Savings in power and time have been made possible by incorporation of the mucilage in place of the mechanical work done on the stock. The expression "pouring hydration from a barrel" is a result of this property. Rowland has reported the many papermaking benefits of guar mucilage.

Use is made of the insoluble complex formed with borax by Smith in the manufacture of a wet-strength paper. After the locust mucilage is added to the beater, the fabricated paper is treated with a borax solution to insolubilize the mucilage.

In addition to the use of mannogalactans as a beater size in the paper industry, they have distinct advantages as adhesives for tub sizing. In order to produce a product from guar mucilage which is suitable as a tub-sizing adhesive, it is necessary to degrade the polymer. Swanson has taken advantage of the insoluble borax-mucilage gel phenomenon in converting the mannogalactans with various oxidants.

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* The term "gum" is used interchangeably in industry with mucilage although "gum" is strictly reserved for pathological and mucilage for physiological plant components. Both terms will be used in this paper.

CONVERSION OF MUCILAGE

Four experimental conversions were made according to the conditions given in Table I.

Table I. Conditions Used in the Oxidations of Purified Mucilage for Tub-Size Adhesives

pH	11.0 ± 0.4
Temperature, °C.	40 ± 1
Gum, g. (oven-dry)	65.0
Gum concentration, % (by weight)	7.25
Borax, g.	19.5

Experiment	*Product*	*Chlorine, g.*	*Chlorine on oven-dry gum, %*
L	L-1	3.25	5.0
M	M-1	6.50	10.0
N	N-1	9.75	15.0
O	O-1	13.00	20.0

The procedure was as follows: The gum was slowly added to the aqueous borax solution, followed by the sodium hypochlorite. The procedure from this point on was similar to those described in Part II of this series. Each reaction was allowed to proceed until 99% of the oxidant was consumed. The products were filtered on large fritted glass funnels and allowed to air dry for at least 48 hr. The material was ground in a

Table II. Yield and Ash Content of Products L-1, M-1, N-1, and O-1

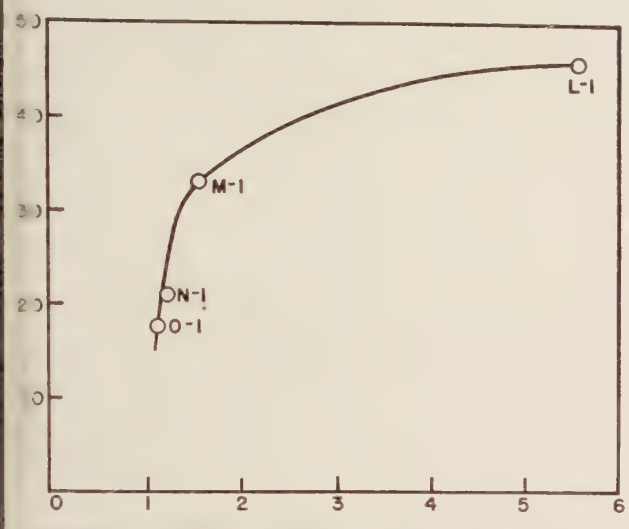
Product	*Ash,*[a] *%*	*Yield,*[b] *%*
L-1	13.6	86.6
M-1	17.6	86.2
N-1	18.8	80.8
O-1	19.9	75.6

[a] Expressed on oven-dry basis.
[b] Expressed on oven-dry, ash-free basis.

ley mill and screened through a 40-mesh screen. isture and ash determinations were made on each ple and the yield of converted product calculated. e results are presented in Table II.

PREPARATION OF PRODUCTS FOR TUB SIZING

A so-called "cooking" procedure is required prior to e sizing operation. On addition of the material to ter, a suspension results and addition of an acid is



g. 1. Increase in bursting strength produced by guar mucilage

cessary to neutralize the borax. A heating period llows to insure complete dispersion of the mucilage. he following directions are given for the procedure:

1. Add 525 ml. of water to a tared liter beaker.
2. Add 47 grams (on oven-dry basis) of product.
3. While stirring, add 3 *N* HCl until the contents e slightly acid (determined by means of alk-acid per).
4. Heat with direct steam to 80 °C. and maintain this temperature for 15 to 20 min.
5. Add water to give a 5% concentration of adhe-e, by weight.
6. Stir for 5 min.
7. Adjust temperature to 60 °C. by means of a steam th.
8. Determine the viscosity at 60 °C. by means of a -ml. pipet. The time of flow between the mark and e end of the constriction of the bulb was measured.
9. Allow the temperature to fall to 57 °C. and then n sizing operation.

TUB-SIZE OPERATION

Tub sizes were made with the products at 5, 3, and % concentrations to evaluate them as adhesives. The ncentrations studied are comparable with those some-mes used commercially in starch tub sizing. A lightly lendered 100% rag sheet containing a small amount rosin and starch size was used in all the sizing tests. The sizing apparatus consisted essentially of a tub, ess or wringer rolls, and a reel. The tub was a flat n with a capacity of 800–1000 ml. The paper was led rough the adhesive by two submerged rolls at oppo-e ends of the pan. The rubber press rolls were approximately 1.75 in. in diameter, and a constant pressure at the nip was used in each operation. The bottom press roll was driven at a constant rate and the paper was sized at the rate of 16 ft. per min. The reel was wound by hand and was constructed so that the paper could be slipped from the core immediately.

About 25 ft. of paper were sized in each experiment. After the paper was threaded through the apparatus, the sizing solution at 57 °C. was poured into the tub and the press rolls were started simultaneously. The equilibrium temperature in the tub was 55 °C. The sized paper was air dried in festoon fashion and then conditioned in the humidity room at 50% relative humidity and 73 °F. for at least 24 hr. prior to testing.

The sizing solution was recovered from the tub and diluted accurately to 3% concentration. By means of a stream bath, the temperature was raised to 60 °C. and the viscosity determined as described in the previous section. The sizing operation was then repeated as outlined above. The same procedure was followed at 1% concentration.

Determination of the Amount of Adhesive Retained by Paper in the Sizing Operation

The amount of converted mucilage retained by the paper was determined in the following manner. The weight of approximately 25 ft. of unsized paper was determined. On this paper a length of 63.75 in. was measured from one end and conspicuously marked. The average weight of the marked portion of the unsized sheet was 17.0 grams (average of 12 determinations). This measured length was threaded through the apparatus at the start of a run. After the paper had been sized and wound on the reel, this marked length was removed and the remaining evenly sized paper was weighed immediately. The average weight of the marked length (17.0 grams) was subtracted from the original weight of the unsized paper.

The difference in the weights of the sized and unsized paper gave the total amount of the sizing solution that had been picked up. Since the concentration of the sizing agent was known, the weight and percentage of

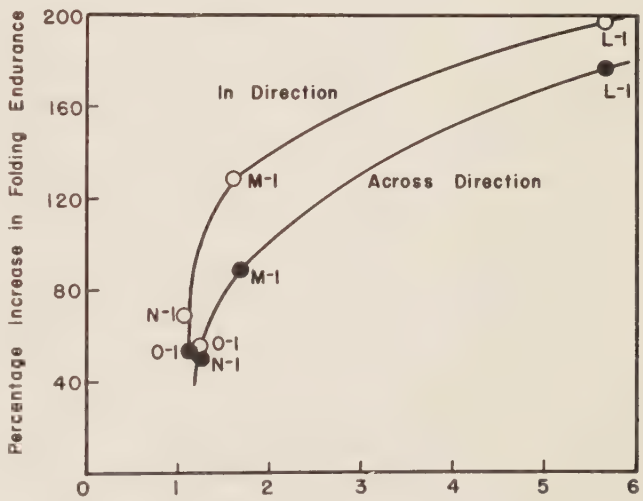


Fig. 2. Increase in folding endurance produced by guar mucilage

the converted mucilage retained by the paper were calculated. The results obtained in this manner are presented in Table III, together with the relative viscosity of the gum sizing solutions at the various concentrations.

Table III. Relative Viscosity and Retention of Products L-1, M-1, N-1, and O-1 in Tub-Sizing Operations

Product	Concentration, %	Relative viscosity	Product retention by paper in operation, %
L-1	5	5.68	1.56
	3	2.24	0.89
	1	1.17	0.30
M-1	5	1.57	1.41
	3	1.25	0.86
	1	1.05	0.30
N-1	5	1.25	1.30
	3	1.13	0.80
	1	1.03	0.29
O-1	5	1.17	1.38
	3	1.09	0.86
	1	1.02	0.27

Paper Testing Results

A sample of the unsized rag paper was used for a blank. Ten determinations were made on each test and the averages of the results are presented in Table IV.

Table IV. Paper Testing Results, Paper Tub Sized with Converted Mucilage Products

Product	Concentration, %	Basis weight, (17 × 22—500), lb.	Bursting strength (Mullen) Points	Bursting strength (Mullen) Points per 100 lb.	M.I.T. fold In	M.I.T. fold Across	Gurley porosity, sec. per 100 cc.	Elmendorf tear, g./sheet In	Elmendorf tear, g./sheet Across	Tear factor In	Tear factor Across	Schopper tensile, lb./in. In	Schopper tensile, lb./in. Across
Blank	...	19.0	30.0	158	174	47	160[a]	94	102	4.95	5.37	25.8	12.9
L-1	5.0	19.3	44.5	231	519	129	224	86	92	4.46	4.77	32.0	16.7[a]
L-1	3.0	18.9	40.8	216	428	95	154	86	99	4.55	5.24	30.4	14.9
L-1	1.0	19.1	36.9	193	244	72	141	88	100	4.61	5.24	24.3	13.8
M-1	5.0	19.4	40.7	210	392[a]	88	143	87	99	4.48	5.10	30.4	14.9[a]
M-1	3.0	19.0	37.8	199	307	80	133	89	100	4.68	5.26	27.4	14.4
M-1	1.0	18.9	34.8	184	280	66	129	93	97	4.92	5.13	26.1	13.7
N-1	5.0	19.4	37.0	191	264	70	135	89	94	4.59	4.85	25.6	14.2
N-1	3.0	19.3	36.3	188	240	68	133	94	100	4.87	5.18	27.3	13.5
N-1	1.0	19.1	34.6	181	243	59	127	94	104	4.92	5.45	25.6	13.1
O-1	5.0	19.5	36.4	187	293	71	129	90	99	4.62	5.08	25.3	14.2
O-1	3.0	19.5	35.4	182	230	66	129	94	98	4.82	5.03	25.6	13.6
O-1	1.0	19.4	32.8	169	260	58	129	92	105	4.74	5.41	26.7	13.3

[a] The average of nine determinations.

DISCUSSION OF RESULTS

Conversion of the purified mucilage in the presence of borax produced a satisfactory adhesive for tub sizing. The product converted with 5% chlorine produced the greatest strength increments in the sized paper and it is probable that even less oxidant would have produced products of still greater adhesive strength. In order to obtain products suitable for tub sizing from the commercial mucilage, Swanson used 12 to 14% chlorine. However, it has been shown in Part II of this series that the greater part of the oxidant was consumed by impurities present in the commercial gum rather than by the conversion of the gum itself.

The data obtained on the bursting strength and folding endurance of the sized paper, as shown in Table IV, were used to obtain the percentage increases of these tests over the blank values. These data are given in Table V and the values at 5% concentration are shown in Figs. 1 and 2. From the figures it can be seen that the ultimate strength of the adhesive was not reached. However, significant strength increases were obtained with products L-1 and M-1 at 5 and 3% concentrations. Increases in the bursting strength up to 46% and in the folding endurance up to 198% in the machine direction and 174% in the across-machine direction were obtained. An increase in the amount of oxidant beyond 5% chlorine degraded the products substantially as measured by relative viscosity, and the strength increases gradually decreased.

Table V. Bursting Strength and Folding Endurance Increases in the Tub-Sized Paper

Product	Concentration, %	Relative viscosity	Increase in burst, %	Increase in fold, % In	Increase in fold, % Across
L-1	5	5.68	46	198	174
	3	2.24	37	146	102
	1	1.17	22	40	53
M-1	5	1.57	33	125	87
	3	1.25	26	77	70
	1	1.05	17	61	41
N-1	5	1.25	21	52	49
	3	1.13	19	38	45
	1	1.03	15	40	26
O-1	5	1.17	18	68	51
	3	1.09	15	32	41
	1	1.02	7	49	23

The porosity of the sheet was not appreciably influenced by the sizing operation. The most viscous size (L-1 at 5% concentration) decreased the porosity whereas, in all other cases, the porosity was increased. It was not possible in this small-scale operation to determine whether the insoluble fraction present in all converted products (approximately 0.5%) was picked up by the paper or concentrated in the tub. However, it did not appear to affect the porosity.

The tensile strength of the sized paper followed the trends shown by the bursting strength, although the effects were not as great. It was interesting to note that the tearing strength of the sheet did not decrease extensively on sizing when the bursting strength and folding endurance were greatly enhanced.

Received May 1, 1952.

These four papers were a portion of a thesis submitted in partial fulfillment of the requirements of The Institute of Paper Chemistry for the degree of Doctor of Philosophy from Lawrence College, 1947. This work was carried out under the direction of Ben W. Roland.

ASSOCIATION NEWS AND EVENTS

Local Section Meetings

Pacific: March 13, 1953, at the Hotel Monticello, Longview, Wash. This meeting will feature papers presented in competition for the Shibley Award.

Lake States: March 10, 1953, at the Northland Hotel, Green Bay, Wis. "Savealls."

Delaware Valley: Jan. 22, 1953, at the Engineers Club, Philadelphia, Pa. Panel discussion on "Development of Paper Properties," W. D. Harrison, Riegel Paper Corp., Milford, N. J., Moderator.

At the March 26, 1953, meeting John R. Curtis of the Scott Paper Co., Chester, Pa., will discuss "Increased Production from Existing Machines."

Kalamazoo Valley: Feb. 5, 1953, at the Harris Hotel, Kalamazoo, Mich. "Fiber Treatment for Strength Development" by James d'A. Clark, Consultant, Longview, Wash.

New England: March 20, 1953, at the Roger Smith Hotel, Holyoke, Mass. Meeting devoted to the presentation of routine control methods.

Empire State: June 8–10, 1953. Annual meeting at Whiteface Inn, Lake Placid, N. Y.

Empire State, Northern District: Feb. 12, 1953, at the Woodruff Hotel, Watertown, N. Y. Annual Ladies Night and Valentine Dance and Entertainment.

On March 12, 1953, W. F. Luckenbach, Jr., of the Virginia Smelting Co., West Norfolk, Va., will talk on "Sell for America."

Empire State, Western District: Feb. 4, 1953. Tour of the mill of the International Paper Co., Niagara Falls, N. Y.

Empire State, Eastern District: Feb. 12, 1953. Panel discussion of routine control methods.

Maine-New Hampshire: June 19–20, 1953. Joint meeting with the New England Section at the Poland Spring House, Poland Spring, Me.

Lake Erie: Feb. 20, 1953, at the Hotel Carter, Cleveland, Ohio. "Cost Saving Equipment for Today and Tomorrow."

Southeastern: Jan. 23, 1953, at Charleston, S. C., and March 20, 1953, at the Hotel Dempsey, Macon, Ga.

Ohio: Feb. 10, 1952. Address by Francis J. Curtis, Vice-President, Monsanto Chemical Co., St. Louis, Mo.

Technical Section, Canadian Pulp and Paper Association: Summer meeting at Saranac Inn, Saranac, N. Y., on June 4–6, 1953.

American Pulp and Paper Mill Superintendents' Association: June 9–11, 1953, at Atlanta-Biltmore Hotel, Atlanta, Ga.

Committee and Section Appointments

Charles J. Sibler of the West Virginia Pulp & Paper Co. and General Chairman of the TAPPI Engineering Division, has made the following appointments in the division:

Curt A. Young, Manager of the Engineering Departments of the Riegel Paper Corp., Milford, N. J., Chairman of the Drying and Ventilating Committee, succeeding M. L. Barker of the Beckett Paper Co., Hamilton, Ohio.

W. M. Wyburn in Charge of Engineering, Federal Paper Board Co., Bogota, N. J., Chairman of the Steam and Power Committee, succeeding H. R. Arnold of the Riegel-Carolina Corp., Acme, N. C.

Phillip E. Nethercut of the Scott Paper Co., has been appointed Secretary of the Delaware Valley Section, succeeding Ann Steinbinder of the Riegel Paper Corp.

William Conant of the Monsanto Chemical Co., Cincinnati, Ohio, has succeeded R. D. McCarron of Morningstar-Nicol, Inc., who is now located in Boston, Mass.

Roger C. Griffin Awarded TAPPI Medal

The Executive Committee has announced the selection of Roger Castle Griffin of Needham, Mass., to receive the TAPPI Medal at the Annual Meeting luncheon on February 19.

Mr. Griffin was born in Montclair, N. J., on Sept. 11, 1883, and graduated from Harvard University (magna cum laude) in 1904. He received his A.M. degree in 1905 and S.M. in chemistry in 1906. During time in the Harvard Graduate School he held the Austin Teaching Fellowship and the Mallinckrodt Scholarship.

After one year as chemist for the Mallinckrodt Chemical Works in St. Louis, Mo., he joined the staff of Arthur D. Little in Boston in January, 1909. This firm started in 1886 as a partnership under the name of Griffin and Little. The senior partner was his father, Roger B. Griffin, who had been superintendent of the first sulphite mill in the United States. The firm was later incorporated under the name of Arthur D. Little, Inc., and moved to Cambridge, Mass., in 1918. R. C. Griffin was a Director of this corporation for 20 years, Treasurer for 9 years, and Vice-President for 3 years, retiring on Jan. 1, 1949, after 40 years of service. He was a Director of Skinner & Sherman, Inc., from 1939 to 1949.

In association work, Mr. Griffin was a member of the American Chemical Society since 1909. He organized Committee D-6 on Paper for the American Society for Testing Materials and served 4 years as its first chairman (1937–40). He was a member of the ASTM Executive Committee from 1940 to 1942.

He was a member of TAPPI from 1915 to 1918 and since 1926. From 1929 to 1932 he was Chairman of the Nonfibrous Materials Testing Committee and General Chairman of the Testing Division from 1933 to 1936. He has been Chairman of the Standards Committee since its inception in 1933. From 1936 to 1941 he was a member of the TAPPI Executive Committee and was Chairman of the New England Section in 1936.

His famous book "Technical Methods of Analysis" was published in 1921, the second edition in 1927. This book was probably the first of its kind to include specifications and other data on various materials as a guide in the interpretation of analytical and test results. It contains a chapter of over 100 pages on the analysis of wood, paper, and papermaking chemicals. In addition, he published some 20 articles having to do with analysis and testing in various technical journals, and the annual reports of the TAPPI Standards Committee since 1936.

Mr. Griffin married Marion Neilson in 1917 and has three children and five grandchildren. His former hobbies included tennis, baseball, football, bridge, and stamp collecting.

One of the principal accomplishments of the Technical Association has been the development of its Standard Testing Methods, Specifications and Recommended Practices. Although a large number of Association members have assisted in the preparation of the Standards, their final excellent form has been due, for the most part, to the careful editing of Mr. Griffin.

College Functions

The Institute of Paper Chemistry Alumni Dinner will be held in the Lexington Terrace, Hotel Lexington, New York, N. Y., on Monday, Feb. 16, 1953, at 6 p.m.

The University of Maine and the College of Forestry, State University of New York, pulp and paper alumni groups will hold a joint luncheon on Wednesday, February 18 in the Hendrick Hudson Room of the Hotel Roosevelt.

The Massachusetts Institute of Technology alumni group will hold its pulp and paper luncheon at the Engineers Club in New York City on Wednesday, Feb. 18, 1953.

Fourth Coating Conference

The Fourth Coating Conference of the Technical Association will be held at the Netherland Plaza Hotel, Cincinnati, Ohio, on May 25–27, 1953. John H. Heuer of the Great Northern Paper Co., Millinocket, Me., is Chairman of the Coating Committee which will sponsor the conference.

Eighth TAPPI Paper-Plastics Conference

The 8th TAPPI Paper-Plastics Conference held at the State University of New York College of Forestry at Syracuse, N. Y., November 5 and 6, proved unusually successful. Despite the fact that the Conference immediately followed Election Day, it was very well attended, there being 212 persons on hand, 194 of them from out of town, including an exceptionally good representation from New England, the middle Atlantic states, and the Middle West.

The program was arranged by Edwin C. Jahn, Associate Dean of the State University of New York College of Forestry and Chairman of the TAPPI Plastics Committee, Herman Mark, Director of the Polymer Institute, Polytechnic Institute of Brooklyn, and Ralph Nazzaro, Director of Research, Westfield River Paper Co.

The program was divided into four sessions. The first was on "Fundamental Resin Problems" given on the morning of November 5 with R. Lindenfelser of American Cyanamid Co. as chairman. B. Rånby of Polytechnic Institute of Brooklyn spoke on "Recent Studies on the Morphology of Cellulose Fibers and Their Significance for Fiber to Resin Bonding." He discussed recent ultrasonic sound techniques in the study of cellulose fibers. R. T. Dean, Interchemical Corp., discussed "Polyester Resins and Paper Laminates" and Professor H. Mark of the Polytechnic Institute of Brooklyn spoke about "Recent Progress in Measuring and Interpreting Adhesion," especially German researches underway.

R. T. Nazzaro, Westfield River Paper Co.; J. J. Aid, Robert Gair Co.; Joseph Pullman, American Cyanamid Co.; Norman Greenman, Rogers Corp.; C. A. Clark, B. F. Goodrich Chemical Co.; and P. H. Yoder, Pyroxylin Products Co.

Richard Lindenfelser, American Cyanamid Co.; E. C. Jahn, State University College of Forestry; B. G. Rånby and H. F. Mark, Polytechnic Institute of Brooklyn; and R. T. Dean, Interchemical Corp.

The second session in the afternoon of November 5 dealt with "Special Resin Systems and Technical Problems" with R. T. Dean of Interchemical Corp. as chairman. A. J. Barry, Dow Chemical Co., discussed "Properties and Uses of Silicone Resins" while F. L. Graves, American Cyanamid Co., talked on "Abrasion Testing on Decorative Laminates with the Armstrong Abrader." R. Lindenfelser, American Cyanamid Co., spoke on "A Melamine Type Resin for Beater Addition Process to Form Laminated Sheets or Molding Preforms" and on melamine resins in general for paper laminates.

Both the morning and afternoon sessions on Thursday dealt with "Plastics Applications to Paper" with R. T. Nazzaro, Westfield River Paper Co., as chairman. In the morning four papers were presented. Frank W. Egan of Frank W. Egan and Co., read R. C. Sturken's paper on "Machinery for Coating Paper with Plastics." This paper was illustrated by colored three-dimensional slides. P. B. Davidson of the Mellon Institute discussed starch and gum coatings in a paper entitled "From Art to Science in Envelope Manufacture." R. W. Reiter of the National Adhesives Division of the National Starch Products Co. discussed "Some Applications of Vinyl Acetate Polymers to Paper." The final morning paper was on "Methods of Reverse Roll Coating" by R. F. Vokes of the Dilts Machine Works.

The final session was held on the afternoon of November 6 and was a panel discussion of "Problems in Application of Resins to Paper." The panel was composed of the speakers of the morning together with some members of the Subcommittee on Plastics in Paper Converting. Special short talks were given by Joseph Pullman of American Cyanamid Co., Paul Yoder of Pyroxylin Products Co., Norman Greenman of Rogers Corp., and Joseph Aid of Robert Gair Corp.

Luncheons were held each day at Drumlins Country Club. Dean H. L. Shirley of the State University of New York College of Forestry gave a short address of welcome at the luncheon on November 5.

Many delegates availed themselves of the invitation of the Dilts Machine Works to visit their new paper coating laboratory at Fulton, N. Y. Special guided tours were made late in the afternoon of both days.

Dilts laboratory personnel, sales engineers, and staff conducted 110 TAPPI men through the Dilts Machine Works laboratory and manufacturing facilities at Fulton, N. Y.

The new coating laboratory is the latest addition to the Dilts laboratory facilities. It was first opened in April, 1952, and its facilities have been used by many paper, fabric, and plastic converters for wide range coating applications.

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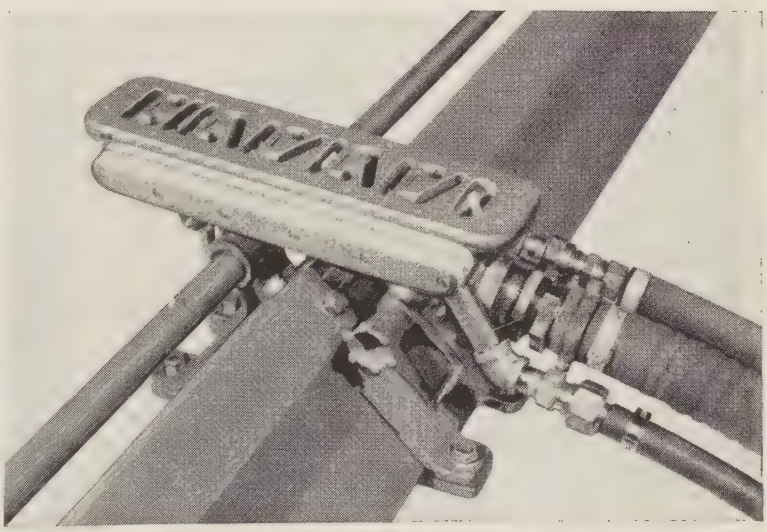

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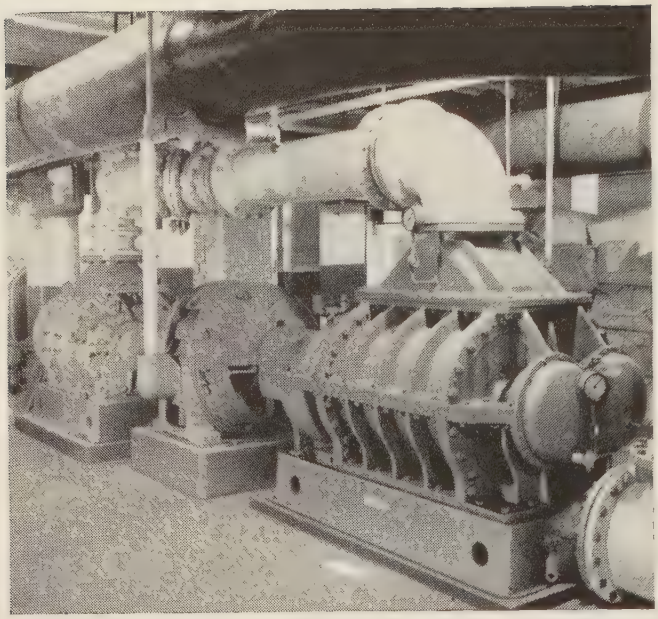

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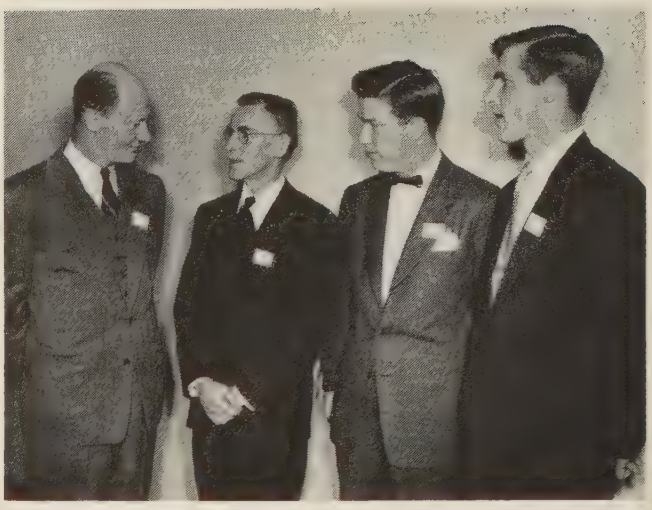


A. J. Barry, Dow Chemical Co.; P. B. Davidson, Mellon Institute; L. W. Egan, F. W. Egan & Co.; and R. W. Reiter, National Starch Products Co.

The coating line features a new-18 in. Dilts "Contracoater" reverse roll coater complete with constant tension unwind and wind, oven and after cooling. The complete coating laboratory is available for pilot plant scale trial purposes, and production of commercially equivalent coated products.

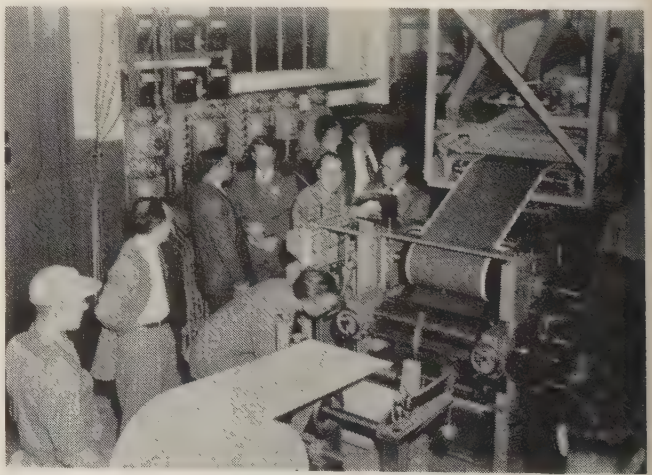
The visiting TAPPI men were conducted through the Dilts shops and the stock preparation laboratories as well as the coating laboratory pilot plant installations. At the time of the visits the new coating equipment was in continuous operation producing a decorative paper useful for store window display advertising and coated with a bright red organisol—one of many such coatings successfully applied by the "Contracoater" reverse roll coater.

The group was transported via chartered buses to and from Syracuse and was entertained at dinner by the Dilts staff at the Fulton Chamber of Commerce.

EDWIN C. JAHN, *Chairman*
Plastics Committee

Fibrous Agricultural Residues Conference

The TAPPI Fall conference on fibrous agricultural residues was held at the Northern Regional Research Laboratory, Peoria, Ill. This is one of the four Regional Laboratories operated by the Bureau of Agricultural and Industrial Chem-



Group visit to the Dilts Machine Laboratory, Fulton, N. Y. during the Plastics Conference

st y of the U. S. Department of Agriculture for better utilization of farm crops. The meeting was held on October 27–28 nd was attended by more than 70 mill men, chemists, engineers, and equipment manufacturers.

Included in this group was a delegation of 12 representatives f the Netherlands straw and paperboard industries who were isiting this country under the auspices of the Mutual Security Agency. This group was led by J. Koski, Project Manager Productivity and Technical Assistance Division, Mutual ecurity Agency, Washington, D. C., and had J. N. Trenité f the Mutual Security Agency as interpreter. The Netherands delegation consisted of four executives, four technical nen, two operators, and two union officials who came to this ountry to study production and labor relations of the Ameri- an strawboard and paper industries.

After the usual self-introductions, R. T. Milner, Director f the Northern Laboratory, welcomed the group to the aboratory. He pointed out that this was the fifth meeting f this group at Peoria. He discussed briefly the scope of ork at the Northern Laboratory with particular attention o the fields of work other than agricultural residues and pulp nd paper. He voiced the hope that this group would return o the Laboratory again at an early date.

W. H. Hosterman, Assistant Chief, Standards Research nd Testing Division, Production and Marketing Administration, U. S. Department of Agriculture, Washington, D. C., hen spoke on "Straw and Hay Standards." He said that he present straw standards were made effective on Jan. 1943, and were set up at the request of the U. S. Army for se as animal bedding. Mr. Hosterman pointed out that ith the advent of the combine for harvesting grain, the haracter of the straw now available is different from that otainable when the standards were set up, particularly ith regard to length of straw, chaff content, etc.

Mr. Hosterman briefly indicated the way the Standards nd Inspection Service was set up and pointed out that the nspection Service was entirely permissive. He said that

G. Landweer, Groningen, Netherlands; S. I. Aronovsky d H. T. Milner, NRRL; R. G. Macdonald, TAPPI; and M. Scott, Asst. Chief, Bureau of Agri. & Ind. Chem., Wash., D. C.

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if the industry desired to have an inspection service for industrial straw, the Department of Agriculture would be glad to cooperate with them, but the demand for such inspection service would have to come from outside the Department.

After Mr. Hosterman's address, the round-table discussion on "Straw Specifications and Grading" was started, based on more than 30 questions sent in by the strawboard industry.

Procurement

The question of shipping by railroad car versus motor truck was discussed, and ways of limiting delivery beyond the unloading capacity of the mill were described. The consensus of opinion was that the best means of controlling deliveries was to set up such control at the source rather than by requesting the railroads or truckers to space their deliveries of the straw. It was reported that at some mills as much as 7000 tons was unloaded in one week and over 300 truckloads in one day.

Baling

The size and density of the straw bale and the type of tie required for stock-piling the straw in ricks were discussed under this heading. Most of those present agreed on 16 × 18 × 38–42 in. as the optimum bale size that can be obtained with the present balers and can be handled fairly easily. Some indicated a preference for a 48-in. bale, but most of the group thought that a standard bale that length would tend to buckle. It was agreed that the density should be approximately 10 lb. per cu. ft., but many claimed that this is difficult to attain at the present time, mainly because many of the balermen get paid by the bale rather than on the weight of the straw baled. All agreed that the farmers and balermen needed to be better informed on the reasons why higher density bales are required by the strawboard industry.

All of the straw buyers present indicated that they were refusing string-tied bales except for immediate current use. Some were refusing string-tied bales altogether. In a discussion on wire ties for baling, it was pointed out that galvanized iron wire is preferred for this purpose and that this wire can be made to meet almost any reasonable specification desired by the baler.

Moisture

Practically all of the straw buyers in the industry use 10 or 12% as the average moisture content of air-dry straw. Most of these straw men use a conductometric portable moisture indicator and pay the farmers on the basis of their readings with this instrument, docking for excess moisture. It was pointed out that this type of conductometric instrument, with the electrodes in a prong would give varying moisture contents depending upon the density of the straw bale, the greater the density the higher the moisture content up to a certain point, beyond which the instrument readings were practically the same as those obtained by oven-drying. This optimum point of density was found to be approximately 10 lb. per cu. ft.

Chaff

It became apparent during the discussion that no one docked the farmers or straw sellers for chaff, if the grain had been combine-harvested. Practically all in the group agreed that in combine-harvesting, the chaff in straw was generally under 5%.

Weeds

It developed during the discussion that most of the strawboard mills allowed 5% weeds in the straw, and docked for a weed content higher than this value. The amount of weeds in the straw is estimated mainly by appearance of the material. Mr. Hosterman pointed out that this was a faulty

thod of determining weed content, since they had found by tual separation of the weeds and weighing them that what d appeared to be 5% weeds was more likely 15–20%. How-r, there is no method available for estimating the weeds her than the laborious one of separation.

pearance

All agreed that a bright yellow color was most desirable ce this indicated fresh, sound straw. It was pointed out y several of the group, however, that the gray appearance f lightly weathered straw did not necessarily detract from soundness of this straw. It is only when the straw was rtly rotted or showed signs of microbial attack that the rties of the pulp produced from this straw were af-ted.

RAGE AND PRESERVATION

Several items were discussed under this heading including e cost of stock-piling straw in the farm area, preservation y various means, spontaneous combustion, and storage s in general. The methods for buying and stock-piling w in the farm areas differ with the various mills. Some y the farmer outright for the straw; others give the farmer rt payment, with the remainder to be paid on delivery of w to the mill.

Many of the mills have tried various types of cover for aw ricks including sisalkraft paper, tarpaulins, loose straw, d metal. Most of the mills have given up the idea of verings as too expensive, but one mill indicated that it was arting to use metal covers, figuring that, extending over veral years, this would be the cheapest method of preserv-g the straw. Most of the mills are using crude borax to rotect the top surfaces of the ricks stored for periods up to a ear. All of those present indicated that for storage beyond e year, additional protection would have to be given the ps of the straw ricks.

One mill reported what appeared like spontaneous combus-on in two ricks of dry straw this year. A representative om the Netherlands said that in all of their experience they d never had a straw rick fire caused by spontaneous com-stion and that practically all of their straw fires were due carelessness of one sort or another.

YPES OF STRAWS

Most of the strawboard people present preferred wheat d rye straws. Some stated they would not take rice straw der any circumstances. Others said that is is impossible obtain wheat straw without getting some oat straw mixed th it. The consensus of opinion was that the straws in order decreasing usefulness for strawboard production are wheat d rye, oats, rice, and barley. A Netherlands man stated at they preferred rye straw, which gives them the strongest lps.

The round-table discussion was quite lively with nearly eryone present taking an active part in the discussions.

At the annual dinner on Monday evening, October 27, e chairman, S. I. Aronovsky, introduced the several akers. Mr. Koski described the tour of the Netherlands egation thus far and pointed out that they had been re-ved very cordially by everyone. D. G. Landweer, Owner-naging Director, Scholtens Board and Paper Mills, roningen, Netherlands, spoke briefly on the strawboard and aw paper industries in the Netherlands and pointed out t straw is their main indigent raw material for pulp and per production. F. M. Muller, Director, Netherlands periment Station for the Utilization of Straw, Groningen, therlands, described the work of his station on the utiliza-n of straw, particularly for pulp and paper.

The speaker of the evening, C. O. Smith, Industrial Engi-r, Hiram Walker and Sons, Inc., Peoria, Ill., in discussing That We Expect of Corrugated Shipping Containers" nted out that the standard tests such as crush resistance,

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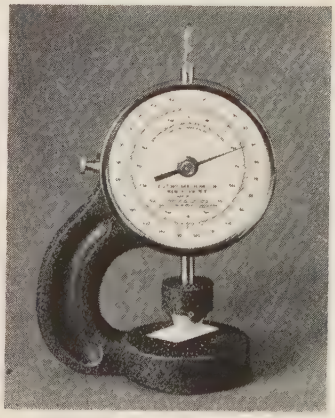

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bursting strength, puncture resistance, etc., as carried out in accordance with TAPPI and ASTM procedures did not always indicate what the fiber containers would do under actual conditions. He referred particularly to the high humidities generally prevalent in packaging and storing distillery products. He pointed out that while he was not using straw corrugating in the shipping containers for whiskey at the present time, these specifications were based upon performance rather than on a preference for any type of fiber. The Hiram Walker Company would prefer to use other materials that would meet their specifications so that they would not be dependent on one type of fiber for their containers.

The second day's sessions covered reports on committee activities. These were discussed briefly by the chairman and tentative plans were made for the Spring meeting in New York in February, 1953, and for the Fall meeting that year. The subject of the 1953 Fall meeting will be "Crush Resistance and Other Properties of Corrugating Strawboard."

A committee meeting will be held at the Spring 1953 TAPPI meeting in New York at which time the subject matter for a proposed TAPPI-sponsored project would be discussed.

The 1952 meeting ended with a tour of the Northern Laboratory. This year's Fall meeting was the fifth held at the Northern Laboratory. The group attending was very interested as indicated by practically everyone present joining in the frank and lively discussions. All indicated that they enjoyed the meeting, which was run pretty much in accordance with the printed schedule. Considerable credit for the smoothness with which this meeting was run is due to the cooperation of the Northern Laboratory staff who assisted in every possible way with the Laboratory's facilities to make this meeting successful.

S. I. Aronovsky, *Chairman*
Fibrous Agricultural Residues Committee

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Robert E. Adams, Construction Engineer, National Container Corp., Jacksonville, Fla., a 1939 graduate of Berea College.

Otto H. Alderks, Manager, The Buckeye Cotton Oil Co., Wyrydale, Ohio, a 1924 graduate of Iowa State College.

Clarence H. Anderson, Project Engineer, Chas. T. Main, Inc., Boston, Mass., a 1951 graduate of Lincoln Technical Institute.

Douglas B. Armstrong, Sales Engineer, R. T. Vanderbilt Co., Inc., New York, N. Y., a 1950 graduate of Willamette University.

Jesse E. Barnhart, Plant Engineer, Green Bay Paper & Pulp Co., Green Bay, Wis. Attended the University of Illinois.

Lester R. Beeman, Student, Western Michigan College, Kalamazoo, Mich.

Anthony L. Billesimo, Night Superintendent, Mohawk Paper Co., Waterford, N. Y.

Robert W. Bird, Junior Engineer, Union Bag & Paper Corp., Savannah, Ga., a 1952 graduate of Carnegie Institute of Technology.

Peter K. Bloch, Vice-President, Branson Instruments, Inc., Stamford, Conn., a 1948 graduate of Columbia School of General Study.

Richard Boehm, Graduate Student, Institute of Paper Chemistry, Appleton, Wis., a 1950 graduate of St. Olaf College.

George N. Bond, Salesman, National Aniline Div., Allied Chemical & Dye Corp., Philadelphia, Pa., a 1933 graduate of Philadelphia Textile School.

Oscar C. Brauner, Chemist and Chemical Engineer, United Wall Paper, Inc., Marion, Ind., a 1926 graduate of the University of Vienna.

Ying-Pe Chang, Collaborator, U. S. Forest Products Laboratory, Madison, Wis., a 1951 graduate of the University of Michigan with a Ph.D. degree.

Lawrence B. Coates, Assistant Chief Engineer, W. C. Hamilton & Sons, Miquon, Pa.

William P. Conant, Jr., Sales Development Engineer, Monsanto Chemical Co., St. Louis, Mo., a 1945 graduate of Purdue University.

Alexander B. Crawford, Director General, Dept. of Supply and Development, Government of Pakistan, Karachi, Pakistan. Received a Ph.D. degree from the University of Glasgow.

William R. Denman, Jr., Chemist, Everett Pulp & Paper Div., Simpson Logging Co., Everett, Wash., a 1950 graduate of the University of Washington.

Edward R. Dornoff, Manufacturer's Agent, Chicago, Ill. Attended George Washington University.

James McC. Farnum, Technical Representative, Hurlbut Paper Co., South Lee, Mass., a 1928 graduate of Massachusetts Institute of Technology.

Lynwood C. Faulkner, General Superintendent, International Paper Co., Container Div., New York, N. Y.

B. Roy Gibson, Jr., Chemist, St. Joe Paper Co., Port St. Joe, Fla., a 1952 graduate of the University of Florida.

Kermit Greene, Mechanical Engineer, Sherman Paper Products Corp., Newton Upper Falls, Mass., a 1947 graduate of Massachusetts Institute of Technology.

Edward F. Greiwe, Application Engineer, Allis-Chalmers Mfg. Co., Norwood, Ohio.

Lars O. Haeger, Manager, Lilla Edet Paper Mill Co., Lilla Edet, Sweden, a 1951 graduate of Netzlers College, Gothenberg.

Max E. A. Hery, Manager, Hery & Co., Paris, France.

Charles O. Hosterman, Jr., Assistant Superintendent, Pulp and Paper Div., Champion International Co., Lawrence, Mass., a 1932 graduate of Tufts College.

Tony Jurecic, Student, University of North Carolina, Chapel Hill, N. C.

Walter B. Kinney, Section Head, The Borden Co., Chemical Div., Bainbridge, N. Y., a 1934 graduate of Pratt Institute.

Richard H. Kirby, Principle Scientific Officer in the Civil Service, Colonial Products Advisory Bureau, London, England, a graduate of London University.

Warren A. Knudson, Vice-President, Silvercote Products, Inc., Chicago, Ill., a 1934 graduate of Armour Institute of Technology.

James G. Lander, Service Engineer, Diamond Alkali Co., Cincinnati, Ohio.

Don Lawson, Resident Engineer, Rayonier, Inc., Port Angeles, Wash., a 1937 graduate of the State College of Washington.

Claude R. Levy, Engineer, CERIC, Paris, France, a 1942 graduate of the Polytechnique College.

Henri Lhomme, Technical Manager, Lhomme & Argy, Draveil, France, a graduate of Ecoles Nationales d'Arts and Metiers.

Joseph E. Mailhos, Plant Engineer, National Container Corp., Jacksonville, Fla., a 1933 graduate of Georgia Institute of Technology.

Myron P. Marander, Chemist, The Dow Chemical Co., Midland, Mich., a 1950 graduate of the University of Washington, and a 1951 graduate of the College of Forestry, Syracuse.

Thomas M. McClellan, Jr., Vice-President and General Manager, Birmingham Paper Co., Birmingham, Ala., a 1920 graduate of the University of Alabama.

John J. McIntyre, Sales Manager, H. B. Fuller Co. of Illinois, Chicago, Ill. Attended Northwestern University.

Dean D. McKinney, Educational Supervisor, Hammermill Paper Co., Erie, Pa., a 1939 graduate of State Teachers College, Clarion, Pa., graduate work at William and Mary College.

Jack E. Meadows, Assistant to the Manager, Crossett Paper Mills, Crossett, Ark., a 1941 graduate of the University of Texas.

Irving Miller, Research Chemist, Plaskon Div., Libbey-Owens-Ford Glass Co., Toledo, Ohio, a 1952 graduate of New York State College of Forestry.

T. Mizunuma, Director, Mitsubishi Paper Mills Co., Ltd., Tokyo, Japan, a graduate of the Tokyo Institute of Technology.

Monroe O. Morris, Jr., Plant Superintendent, Case Brothers, Inc., Manchester, Conn.

Joseph V. Mullee, Chemist, Naval Supply Activities, Brooklyn, N. Y. Attended Columbia University.

Richard J. Nelson, Product Engineer, Westvaco Chemical Div., New York, N. Y., a 1951 graduate of Northeastern University.

Frank E. Newton, Manager, Robert Gair Co., Inc., Cleveland, Ohio.

Ira P. Nicole, Plant Engineer, American Box Board Co.,

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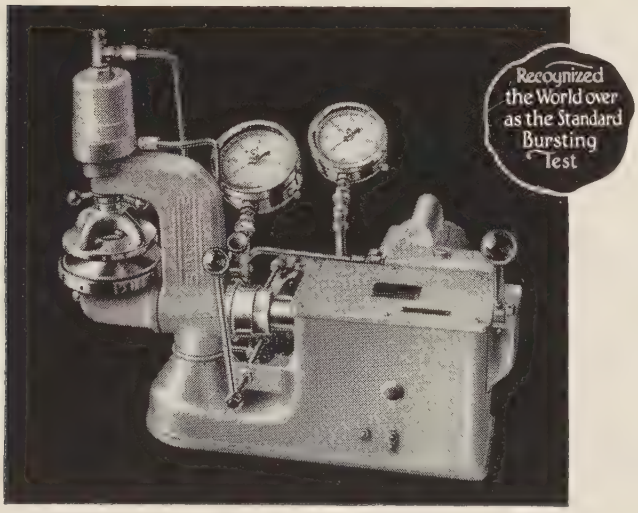

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Edward F. O'Gara, Sales Engineer, Combustion Engineering Superheater, Inc., Chicago, Ill., a 1940 graduate of Worcester Polytechnic Institute.

D. Bruce Otis, Associate Editor, Lockwood Trade Journal Co., Inc., New York, N. Y., a 1942 graduate of Hamilton College.

Vincent P. Petrucelli, Chemical Engineer, Kalamazoo Vegetable Parchment Co., Parchment, Mich., a 1950 graduate of New York University.

Shafiquer Rahman, Student, New York State College of Forestry, Syracuse, N. Y., a 1950 graduate of the University of Dacca.

David W. Reid, Chemical Engineer, Union Bag & Paper Corp., Savannah, Ga., a 1951 graduate of the North Carolina State College.

Dorian F. Reid, Sales Engineer, Catalin Corp. of America, New York, N. Y., a 1938 graduate of Amherst College.

Henry M. Rogers, Engineer, Lockwood Greene Engineers, Inc., New York, a 1933 graduate of Clemson A & M College.

Frank H. Reichel, Jr., Chemist, Ketchikan Pulp Co., Bellingham, Wash., a 1948 graduate of Yale University.

Henry R. Sallans, Senior Research Officer, National Research Council of Canada, Saskatoon, Sask., Canada, a 1934 graduate of McGill University with a Ph.D. degree.

Russell G. Seip, Chief Engineer, St. Regis Paper Co., Pensacola, Fla.

H. Shogaki, Manager, Mitsibishi Paper Mills Ltd., Takasago Mill, Takasago-chu, Hyogoken, Japan.

Sterner C. Soneson, Sales Representative, Virginia Smelting Co., East Norfolk, Va., a 1936 graduate of Lowell Institute.

Meyer Stein, Secretary, Grand-City Container Corp., North Bergen, N. J., a 1926 graduate of Cornell University.

Murray M. Stokely, Electrical Engineer, J. E. Sirrine Co., Greenville, S. C., a 1936 graduate of Clemson College.

K. Tanemura, Director and Chief of Research Laboratory, Toyo Rayon Co. Ltd., Tokyoto, Japan, a 1923 graduate of Tokyo University with an Eng.D. degree.

Charles S. Thorn, Director of Sales, George W. Swift, Jr., Inc., Bordentown, N. J.

Morie Tsuchitana, Factory Manager, Toyo Pulp Co., Hiroshima-ken, Japan, a 1929 graduate of Kiryso Engineering College.

Guglielmo Turini, Managing Director, Cartiere Miliani, Fabriano, Italy.

Charles J. Waechter, Project Engineer, John Waldron Corp., New Brunswick, N. J., a 1950 graduate of Rutgers University.

Kyle Ward, Jr., Research Associate, The Institute of Paper Chemistry, Appleton, Wis., a 1923 graduate of the University of Texas, with a Ph.D. degree from Friedrich Wilhelms University, Berlin, Germany, in 1932.

Edward F. Weiss, Technical Service Representative, Buckman Laboratories, Inc., Memphis, Tenn., a 1952 graduate of the University of Cincinnati.

Bernard P. Wilder, Jr., Treasurer and General Manager, C. R. Whiting Co., Inc., Hackensack, N. J. Attended Northeastern University.

William K. Wilson, Chemist, National Bureau of Standards, Washington, D. C., a 1938 graduate of the University of West Virginia.

Clarke W. Wolfert, Jr., Mechanical Engineer, Weyerhaeuser Timber Co., Pulp Div., Springfield, Ore., a 1951 graduate of Rensselaer Polytechnic Institute.

TAPPI Notes

Wilmer J. Balster, formerly Vice-President of Don L. Quinn Co., has resigned to establish his own consulting practice as The Wilmer J. Balster Associates, 3511 N. Sheffield Ave., Chicago 13, Ill.

LeRoy J. Bauer, formerly with the Pierce Consulting Engineering Co., has established his own consulting practice in Hudson, Mass.

A. P. Bellinghausen is now Technical Control Superintendent of Paper for the Kimberly-Clark Corp., Neenah, Wis.

Daniel D. Cameron, of the PMC Dept., Hercules Powder Co., has been transferred from Wilmington, Del., to Kalamazoo, Mich.

J. Walter Couture is now in Charge of Sales, Northeastern Territory, Black-Clawson (Shartle & Dilts), Fulton, N. Y.

Edwin L. Crowley, Chemical Engineer for Infilco, Inc., has been transferred from Chicago, Ill., to Tucson, Ariz.

Felix Eisenman, formerly of Papierfabrik Biberist, is now Technical Manager of Papierfabrik Utzendorf, Utzendorf, Switzerland.

J. Lynne Ferner is now Manager of the West Virginia Pulp & Paper Co. mills at Williamsburg, Pa., and Tyrone, Pa.

Ralph H. Field is now Director of Quality Control, Keyes Fibre Co., Waterville, Me.

Edwin S. Flinn is now Assistant Director of the Research Dept., Mead Corp., Chillicothe, Ohio.

George E. Fromm, of the American Cyanamid Co., has been transferred from New York to Chicago, Ill., as Western Regional Manager.

Roland A. Gale, formerly with Pittsburgh Mills, Inc., is now Manager of Gale Chemical Products, Yonkers, N. Y.

Gerald A. Hale, formerly Student of Western Michigan College, is now Sales Representative for Edgar Brothers Co., Metuchen, N. J.

Carl A. Hammel, formerly of the Superfine Paper Mills, Inc., is now Assistant General Superintendent of the Chesapeake Paperboard Co., Baltimore, Md.

Matthew F. Healy, Jr., formerly of Kelco Co., is now Sales and Service Representative for the American Cyanamid Co., Mobile, Ala.

H. A. Helder is now Vice-President and Division Manager for the Champion Paper & Fibre Co., Canton, N. C.

R. M. Husband, formerly of the University of Toronto, is now Research Associate with the ESPRA Hardwood Pulping Project, College of Forestry, State University of New York, Syracuse, N. Y.

Walter Jacoby is now Assistant Sulphite Superintendent of the Camas, Wash., Mill of Crown Zellerbach Corp.

W. F. Kallock, formerly Plant Manager of McLaurin-Jones Co., is now with Marvellum Co., Holyoke, Mass.

H. C. Kerman, of Commercials Ltd., has been transferred from Montreal to Gatineau, P. Q.

Howard W. Layman is now Director of Public Relations, The Mead Corp., Chillicothe, Ohio.

Robert L. Leaf, Jr., Resident Manager of the Little Falls Pulp Co., has transferred his office from De Pere Wis., to Shawano, Wis.

William A. MacCrehan, Jr., formerly of the Empire Box Co., now Quality Manager for the Lord Baltimore Press, Baltimore, Md.

Robert D. McCarron, formerly of Stein, Hall & Co., is now Technical Representative for Morningstar, Nicol, Inc., Boston, Mass.

James H. McClure, formerly of Sherman Paper Products Corp., is now Vice-President in Charge of Manufacture for the Industrial Container & Paper Corp., Chicago, Ill.

Parker McIntosh, formerly with the Dominion Paper Co., is now with Sterling Paper Mills, Inc., Kingsey Falls, P. Q.

Alex J. Malashevitz is now Technical Director and Assistant to the Vice-President of Catalin Corp. of America, New York, N. Y.

Felix A. Mariani, formerly with Beach & Arthur Paper Mill, is now with the Modena Paper Mills, Inc., Modena, Pa.

Hoke Martin, of the PMC Dept., Hercules Powder Co., has been transferred from Kalamazoo, Mich., to Portland, Ore.

Ray C. Martin, Consultant, has moved his office from Arlington, Va., to 240 Mt. Vernon Place, Newark 6, N. J.

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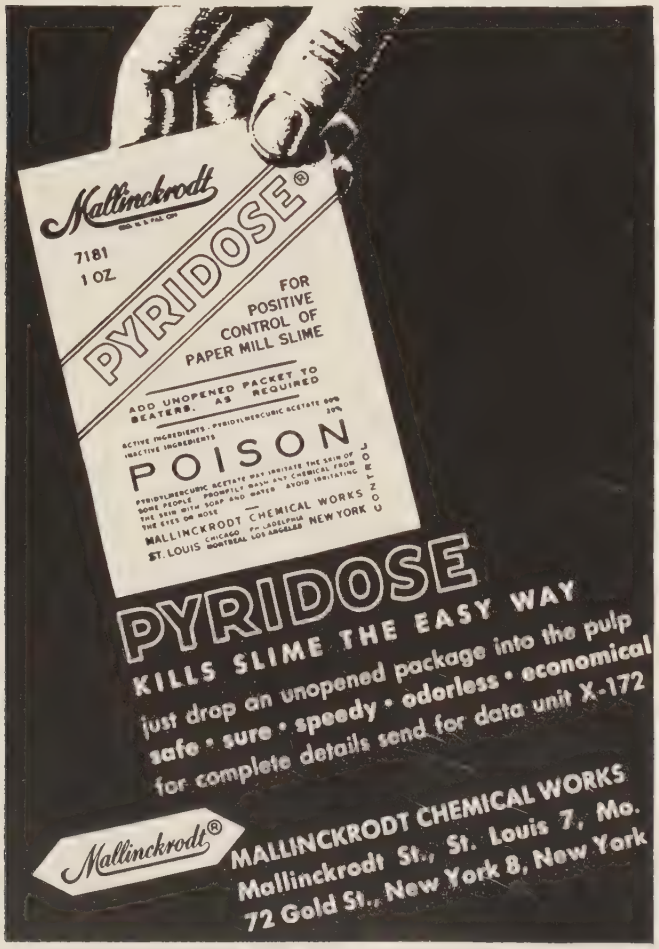
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Edward S. Mason, of the Massachusetts Institute of Technology Chemical Engineering Dept., has been transferred from Cambridge, Mass., to the M.I.T. Station, Eastern Corp., Bangor, Me.

Arthur C. Megalos is now Industrial Engineer for the Constellation Cup Corp., Long Island City, N. Y.

G. W. E. Nicholson is now Executive Vice-President of the Union Bag & Paper Corp., New York, N. Y.

Max R. Oberdorfer is now President and General Manager of the St. Helens Pulp & Paper Co., St. Helens, Ore.

George A. Oechsle, Jr., is now Mill Superintendent of Gair Cartons Div., Robert Gair Co., Piermont, N. Y.

Donald K. Pattilloch, formerly of H. E. Talbott & Co., is now Consultant for Nucel Centralab, 110 Madison Street, Syracuse, N. Y.

Henry J. Perry, formerly of *The Paper Trade Journal,* is now Director of the Waste Paper Utilization Council, New York, N. Y.

Carl F. Richter, formerly of the Stebbins Engineering & Mfg. Co., is now with Delrac Corp., Watertown, N. Y.

Roy D. Rivers, formerly of Thela Commercials S/A, Sao Paulo, Brazil, is now Superintendent of Operations for Ballapur Paper & Strawboard Mills, Ballapur, C. P., India.

Martin M. Scher, formerly of The Napkin Corp., has established his own consulting practice at 2 Peter Cooper Road, New York 10, N. Y.

Douglas W. Shook, formerly of Coosa River Newsprint Co., is now with the Kimberly-Clark Corp., Neenah, Wis.

Herbert A. Smith is now Technical Director of The Mead Corp., Chillicothe, Ohio.

Raymond W. Snyder, of the Champion Paper & Fibre Co., Canton, N. C., is now on military leave of absence.

Siegfried Studer, formerly of Papierfabrik Utzendorf, is now Technical Manager of Balsthal Paper Mills, Balsthal, Switzerland.

Everett C. Uebrick, formerly of the St. Croix Paper Co., is now Pulp Mill Superintendent of the Hoberg Paper Mills, Inc., Green Bay, Wis.

Blanchard D. Warren, Assistant Sales Manager of the Bird Machine Co., has been transferred from South Walpole, Mass., to Portland, Ore.

Robert C. Whitney is now Assistant to the Paper Mill Superintendent, Personal Products Corp., New Brunswick, N. J.

J. Howard Wright, formerly with S. Austin Bicking Corp., is now Sales Engineer for Bauer Bros. Co., Springfield, Ohio.

Kenneth E. Youngchild, of the American Cyanamid, Co., has been transferred from New York, N. Y., to Mobile, Ala., as Southern Regional Manager.

* * *

Sture G. Olsson, President of the Chesapeake Corp. of Va., West Point, Va., has succeeded his father *Elis Olsson,* retired, as the official corporate representative of the Chesapeake Corp. in the Technical Association.

Henry W. Fales, Vice-President and General Manager of The St. Croix Paper Co., Woodland, Me., has succeeded *H. L. Hayes* as the official corporate representative of his company in TAPPI.

Dominique Pelgroms has succeeded *Francois Harmant* as the official corporate representative of Steinbach & Co., S. A. Malmedy, Belgium, in TAPPI.

R. Garnsey has succeeded *Hans Schwetzer* as the official corporate representative of Courtaulds (Ala.), Inc., Mobile, Ala., in TAPPI.

G. D. Grogan, Sales Manager of the Industrial Chemical Dept., Pennsylvania Salt Mfg. Co., Philadelphia, Pa., has succeeded *R. S. Roeller* as the official representative of his company in TAPPI.

A. L. Magnuson, Technical Director of the Paper Dept. of Kelco Co., Chicago, Ill., has succeeded *V. V. Vallandigham* as the official representative of his company in TAPPI.

E. F. Tucker, President of Stebbins Engineering & Mfg. Co., has succeeded *Carl F. Richter* as the official representative of his company in TAPPI.

Industry Notes

Production

Wood pulp production for the first nine months of 1952 was 12 259,000 tons, a decline of 158,000 tons under the production for the same period in 1951. Consumption for the same period was 12,823,000 tons, a decline of 562,000 tons under 1951. Exports totaled 173,000 tons, an increase of 19 000 tons. Wood pulp imports were 1,342,000 tons, a decline of 482,019 tons. Imports from Europe were down 230,798 tons and from Canada there was a decline of 251,225 tons.

Receipts of wastepaper in September amounted to 693,000 tons, the highest monthly receipts since October, 1951. For the first nine months receipts amounted to 5,644,000 tons, a decline of 1,790,000 tons under the same period in 1951. Consumption for 1952 through September totaled 5,734,000 tons, a decline of 1,429.000 tons under the 1951 period.

Pulpwood receipts for the first nine months of 1952 totaled 20 688,000 cords, a decline of 3% under receipts for the 1951 period. Domestic receipts declined 2% and imports 10%. Pulpwood consumption for the nine months amounted to 19,710,000 cords, which was about the 1951 consumption for the nine months.

Newsprint

In spite of increased consumption of newsprint by the nation's newspaper publishers during 1952, availability this year is expected to show a marked gain over 1951.

Production estimates for 1952: U. S. mills, 1,173,713 tons; imports from Canada, 4,857,867 tons; imports from Europe, 190,617 tons, less U. S. exports of 164,661 tons. The total available supply for use is estimated at 6,057,536 tons.

The 1952 figures compared with 1951 production follow: U. S. mills, 1,124,748 tons; imports from Canada, 4,783,549 tons; imports from Europe, 206,319 tons, less U. S. exports of 71,296 tons. Total available supply for use reached 6,043,320 tons.

Newsprint consumption in the U. S. in 1952 appears likely to exceed 5,950,000 tons.

October, 1952, newsprint consumption totaled 525,981 tons as compared with 405,277 tons in the same month of 1951. Stocks on hand and in transit in October, 1952, aggregated a 16-day supply, or five days more than prevailed in October, 1951.

Dominican Republic

Press reports state that the Dominican Republic is to build a paper mill using bagasse as the sole raw material. The plant, to cost $2,500,000, will have an annual production of about 8500 tons. It is said that this tonnage would be enough to supply the country's entire needs of paper, allowing 2000 tons for newsprint, 2500 tons for envelopes, 1500 tons for cartons and boxes, 1000 tons each for cement bags and corrugated paper, and 500 tons for writing paper.

China

Most of the paper mills are located in the northeastern part of China and in Shanghai, and today 49% of these mills are owned by the government and 51% by private industry. Production is very low and only 4% of the mills have a daily capacity of over 50 tons. The paper mills in Tientsin are undoubtedly state-owned and are run along Russian lines with Stachanov-competitions, honor prizes, etc., to stimulate workers' interest. Today there is only one newspaper for each 100 people and in order to have two for each 100 readers, it would be necessary to build 50 new paper mills, each with a daily capacity of 100 tons in order to meet minimum newsprint re-

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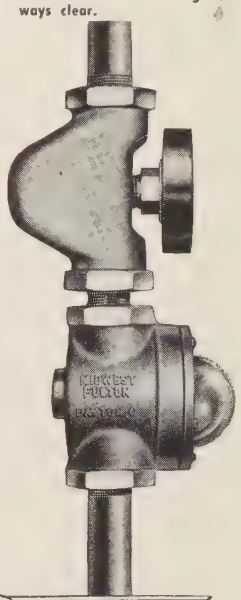

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DAYTON, OHIO

quirements. If every Chinese were to get one book a year it would require an additional yearly paper production of 200,000 tons.

South Africa

The new board mill at Canelands (Durban) Natal, Union of South Africa, is now in production and finely processed fiberboards are being manufactured for the first time in history from Zululand grown saligna gum trees. The other two companies which propose to utilize saligna as a raw material are the $23,800,000 rayon factory at Umkomaas and the $12,600,000 paper mill at Tugela, both of which are still in the process of construction.

India

In 1951 India had a total of 18 mills manufacturing paper and board with additional mills expected to be in production in 1952. Most of the mills have old equipment, but replacement is expected when the present machinery is written off. The major portion of the mills are small. Only seven of the present mills and one of the new mills has a yearly capacity of over 5000 tons, of which four have a 10,000-ton yearly capacity. The largest Titaghur Paper Mills in West Bengal have a yearly capacity of 33,000 tons. The total production in 1925 was 23,000 tons and in 1951 an estimated 130,000 tons.

Discovery of a new formula for the manufacture of "excellent" kraft paper from banana stumps is reported by the Indian Government's Handmade Paper Research Center at Poona, Bombay State. The formula employs a mixed pulp of banana and jute in the proportion of 60 to 40%.

D. C. Everest

At the November 24 meeting of the Salesmen's Association of the Paper Industry D. Clark Everest, Chairman of the Board of the Marathon Corp., gave one of his excellent talks dealing with the immediate future of the paper industry. Exerpts from Mr. Everest's talk follow:

When one is fortunate enough to have been connected with the industry for 53 years, naturally he sees many changes — changes in almost every phase of the business. Having lived in the business for that length of time, one is supposed to be able to predict what is to happen over both the short and long-range periods. That might be true under so-called "normal conditions." Unfortunately, "normal conditions" have not existed for some time and this business of "forecasting" becomes both difficult and dangerous....

I do not know why it is, but if some fellow on some prominent newspaper pecks out a story of some dire thing that is to happen to the American economy, all the rest of the writers take up the same theme and soon we have the majority of people thinking we are headed for a depression in spite of hell and high water. I think we talk ourselves into bad situations. Constant repetition of predictions of a recession has a decided effect on the "weak-kneed sisters" and they usually take action which precipitates such a condition.

Several years ago I said the industry was afflicted with "a cash register complex" and if the sales for each succeeding day were not greater than the day before—we were sure that business had "gone to hell in a hand basket." I am not sure that we have recovered from that affliction.

No one can expect "receipts of business" to be always on the upward trend. There are bound to be some slight recessions, but in the paper and paperboard business, so long as we have a population of 158 million, which is increasing at the rate of nearly three million per year, we are not going to have any serious difficulty unless we create it ourselves.

We used to think that operations on a basis of 85% of capacity were pretty good; but now everyone seems to be struggling for 100% operation and with a backlog of orders piled up for another 30- to 90-day operation.

I know of no industry in which such a condition is maintained—then why expect it in this industry? As I see it, with the increase we have had in productive capacity plus that which is in the course of construction, it is about time to take a breathing spell and appraise the supply and probable demand.

We all know that we cannot do a sound expansion program based on a war economy. Such an idea is fallacious. I think industry generally has gotten into the habit of using rather faulty estimates as the basis of future planning—as James Redfield has said, "Estimates that reflect the sales manager's optimism on the one hand, and the controller's or production manager's conservatism on the other. In either case these estimates are likely to be highly subjective and, as a result, biased by the distinctly human tendencies toward caution, self-preservation, or the desire to please."

Perhaps the overexpansion in productive capacity may be accounted for in this way. Today, through the medium of trade associations and government agencies, we have complete statistical data on production and sales of nearly every grade of pulp, paper, and paperboard. If the trend indicates that there is an evident annual demand for an additional hundred thousand tons of some particular product and, say four concerns of equal financial ability each decide they will expand to meet this added demand, then we have four times as much added capacity as the statistical data indicated the market would absorb.

It is these situations which create these "periods of indigestion" which are so upsetting to you as salesmen and to management as guardians of stockholders' money. Let me interject here that regardless of the effect on my business through such action I much prefer it to any form of government control.

All this simply means that we must learn to do business based on the immutable law of supply and demand and forget the idea that any artificial means of "lifting ourselves up by our boot straps" is workable. We must get back to "free competition" which we have all been crying for and meet the situation through our own efforts along the lines of initiative, inventiveness and just good old-fashioned hard work. In all probability, with present-day productive capacity, the days of "allocation of tonnage" to customers are over, at least for some time to come.

There is also the problem of dealing with statistics in the three over-all groups of pulp, paper, and paperboard without careful analysis or breakdown of the several grades within the three major classifications. It is only within the last ten years that the Bureau of the Census figures have been broken down into the several grades. The figures as now reported should impress anyone who studies them, with the complexity of this industry.

When I got into this industry, the total consumption of all grades of paper and paperboard was 2,167,000 tons; now it is running at the rate of more than 31 million tons or more than fourteen times as much; whereas population has only increased about 2.1 times. The use of paper and paperboard has therefore increased seven times as much as the population.

Another interesting fact developed by a careful survey of the statistics is that in 1900, 43.6% of the consumption in tons was in printing papers and 33.7% in packaging papers and boards. Today the situation is reversed. In 1951, printing papers accounted for only 30.5%, whereas paper and paperboard used for packaging amounted to 44.7% of the total consumption.

This does not mean that the use of printing papers has not kept pace with the use of packaging, but in dealing with these percentages we refer to tons of paper consumed. If we had any means of determining the number of square feet of printing surface used, we would find that printing papers still lead the procession so far as increased end product use is concerned.

Through research and development, the products furnished to the publication field have been completely changed. Restrictions on the use of pulp and other raw materials in two world wars forced a reduction in weight of papers in the publi-

cation business which has now become common practice. About the only things left in weights ordinarily used 50 years ago is in newsprint and writing papers. So long as newsprint is manufactured in the conventional way there will probably be no appreciable reduction in weight, as we seem to have reached the minimum weight when we consider opacity and workability.

In other fields there are and will be constant changes as new processes and mechanical improvements are devised. As a sidelight on this matter of research and development within the industry, I well recall that in 1915 a few of us who were interested in injecting more scientific technical development into our business, and were trying to organize the Technical Association, found that there were about 30 technically trained people who were gainfully employed in technical research by paper companies. Today there are close to 5000 members in TAPPI. Therein lies your answer as to why and how the paper industry has run so far ahead in the use of its products in comparison with the increase in population. It is also both the assurance and the insurance that the industry will continue to grow through new developments, some of which we may not dream of at this time.

Don't get the idea that I attribute all the increase in our business to TAPPI. There is another organization known as SAPI which is entitled to great credit for the growth of the industry. Technicians may devise new products, but someone must make the buying public realize that they need these products. That is your function and sometimes it is even more difficult than thinking up a new product. Many times the idea that the need for a new product or new use is imminent originates with the salesman. The sales and technical divisions complement each other.

Getting back to changes in trends of use, there are not many significant changes so far as percentage of tons is concerned. Aside from newsprint and all rag writings, there is not one single item which is being made from the same materials or in the same way they were made at the turn of the century. Even these are being made from different woods and grades of rags.

In fact, I doubt if the bulk of the papers and products sold today are based on the specifications and formulas used at the close of World War II. This industry is prepared to cope with any new physical characteristic needed for any service wherein it is sensible to use paper. Of course, some imaginative person can write specifications which no one can meet, but I stark back to the statement I have made so often: "There is no economic substitute for paper and paperboard, but they are the economic substitutes for many other materials and products."

To get down to the short and long-range outlook for the industry and the predictions which many people are making through weekly services to which we all subscribe, it strikes me that these people must necessarily deal with an over-all picture and predicate their views on many factors about which they are not too well informed. Nearly all of them say there will be a decline in business during the last half of 1953. The more cautious ones inject a lot of "ifs," but the headline writers overlook the "ifs."

If a person is only a "headline reader," he can be in hot water most of the time. Of course, I know that if general business is off, the paper industry will suffer, but I doubt if it will suffer to the same extent as many other industries. There are several branches of the industry which may gain in such a situation through substitution of their products for more expensive ones. In periods of recession, if they last for any appreciable length of time, the American people do pay more attention to economics.

Most of these analysts predicate their forecasts on defense spending. No one on earth can tell definitely about the amount, nor when this money will be spent. Again, there are too many "ifs" in the picture. We do know that with the world situation in the mess it is today, this type of spending is not coming to an abrupt ending. I hate to think that our economic outlook is geared to government spending, but that is the way it is and no miracle is going to happen within one year or two years to completely change this.

I do not think we have yet felt the impact of furnishing the military effort in Korea with new material. I have been advised by those who should know that, up until May of this year, nearly 70% of the equipment used in the Korean campaign was left over from World War II and had been rehabilitated here and abroad. As this rehabilitated equipment is used up it means *all* new equipment for replacement. While the placement of orders for military use may be declining, there is a pent-up backlog of orders which has not been filled and the money expended by the government which helps buying power has no effect until these things are actually made and delivered.

We also know that spending in government is an entirely different proposition than current spending in industry or on the part of the people. Government has commitments which run through next year and until whatever they have contracted for is made and delivered. These commitments are being made constantly and will continue—until something happens to obviate the necessity for a defense program. It seems more likely that this situation may develop into an offensive program. Regardless of whether it is a defensive or offensive program, it will require a vast quantity of goods and equipment and will finally taper off rather than end abruptly.

After the lesson we should have learned through the unwarranted demobilization of the military in 1945, and particularly with one so skilled in military matters directing the affairs of government, I am confident that we will not again make the mistake of such drastic demobilization. If the military forces are maintained until such time as they may be demobilized in an orderly fashion without injury to the country's welfare, then we shall have a gradual transition from military to civilian use without upsetting our whole industrial situation. The increase in population each year will also have a softening effect on any extended recession the economists are fearful of.

I have more concern about the amount of goods which may be brought into this country from countries which have received assistance from the United States in rehabilitating their plants and have been given all of our "know-how." With the wage rates in effect in those countries in comparison with ours and the fact that during the Roosevelt-Truman administrations tariffs have been cut drastically through their monkeying with these reciprocal trade agreements, there is no question but that the foreign-made goods will have a decided price advantage over goods made within the United States. I look for an influx of goods from abroad which may have a decided effect on our domestic production of goods.

In substantiation of my contention, I would call your attention to what happened in the rayon industry last week. Manufacturers reduced their prices on synthetic yarns three cents per pound. As I understand it, two cents of this reduction was to meet the foreign competition and the other cent to establish a new low to try to keep out the imports.

It is a cinch that the United States cannot absorb all of the excess goods made abroad plus those produced in this country, and I am more fearful of the impact of those goods coming in here than I am of any sudden shift in demand within this country. Astute labor leaders in some lines of industry are already complaining about the impact of importations on employment in their particular fields. Perhaps I am more impressed with this possibility on account of my being a Republican and still believing in protective tariffs for American workers and industry.

I do not look for much upset in our own industry as pulp and newsprint have been on the free list since 1913. The only bad effect on our business will come through the price route on other grades. Some countries do have the advantage of lower wood costs and wage rates, although they also have some disadvantages in the cost of coal and chemicals.

Any interruption in domestic production does react on the paper and paperboard industry.

As to the outlook for the immediate future, I believe that consumption for 1952 will run in excess of 31 million tons and that 1953 will exceed this by 2 to 3%. I include in this figure representing "consumption" something over five million tons of imported newsprint.

As to the long-range consumption, I do not think we can expect it to continue at the same rate of increase each year as it becomes increasingly more difficult to find "new uses." This field has been pretty well covered, but there are still a lot of smart people working on new products and uses. I think one might tie the estimated increase in consumption to the actual increase in population. My "guestimate" is that by 1960 consumption will have reached approximately 42 million tons, 35 million tons of which will be manufactured in this country.

As to whether profits may be materially affected over the long-range period depends entirely on how fast additional productive capacity may be added. If this is done in an orderly fashion to meet demand and people realize that they can't operate 100% regardless of general business conditions, then I believe profits will be maintained on a reasonable basis. For 1953 I see nothing tangible to change my thinking that we will have a very satisfactory rate of operation and profit. If this does not materialize, I think you will find that the cause will be some foolish action on the part of someone who has the "cash register" complex in relation to receipts of business. Of course with plenty of productive capacity in practically every division of the industry, everyone will have to work for his share of the business.

Nekoosa-Edwards

Stream conditions more favorable for fish were found by scientific measurements of Wisconsin River water below this town within a few days after Nekoosa-Edwards Paper Co. began pumping into lagooning ponds 200,000 gal. per day of spent sulphite liquor which previously flowed into the river, the company announced recently. The sulphite liquor now goes into a series of diked-in ponds that the company constructed on an island some distance from its sulphite pulp mill.

A stainless steel pipe line 4 in. in diameter and 2000 ft. long was completed recently and pumping began immediately. In these ponds much of the liquor soaks into the earth and what remains is subject to weathering which soon removes most of the oxygen-consuming ingredients.

Liquor is being pumped through the pipe line at a rate ranging between 100 and 200 gal. per minute for 24 hours a day while the pulp mill is operating. During week-end shutdowns of the mill, a smaller flow will be maintained through the pipe line to prevent a freeze-up.

Nekoosa-Edwards Paper Co. conducted extensive surveys of river conditions above and below its sulphite mill for $2^1/_2$ mo. while the pipe-line project was engineered and built, in order to obtain facts for judging how effective its new method would prove in reducing sulphite pollution.

Gair Cartons

Almost as dramatic as the stirring history of the Colonial and Revolutionary war periods in Piermont and Rockland County is the story of the growth of Piermont's largest industrial plant, Gair Cartons Div. of Robert Gair Co., Inc., which celebrates the 50th anniversary of its founding this year.

In the early part of 1901, Martin R. Williams, a boxboard manufacturer from Chicago, was in the neighborhood of Piermont on a business trip and recognized its possibilities as an ideal spot for a mill. The town had good transportation facilities by water, road, and rail, had an ample fresh water supply, and was in an excellent labor market. So, in 1901, he signed a long-term lease on property used formerly by the Erie Railroad as a terminus, but at that time unoccupied. This lease on the land continued in effect for more than 40 years when the property was sold by Erie to the Gair Co. in 1943.

Mr. Williams' son, Chase E. Williams, came east to assist his father in the management of this new venture, and John (Jake) Muirhead of the Chemical Paper Co. joined the two as mill superintendent. A building was erected for the installation of two paperboard machines, and no. 1 machine began making board on Lincoln's birthday, Feb. 12, 1902. No. 2 was ready very soon thereafter. The estimated total production of the two machines was about 50 tons per day but, from the start, it exceeded the estimated daily capacity. In 1905, Martin Williams passed away and his son took charge of the plant—remaining in that position until the merger with Gair in 1920. In 1912, a third machine was put into operation, and by 1920 a total production of 220 tons a day had been attained and the personnel rose to approximately 350 workers.

At that time, along with the paperboard mills at Haverhill and Thames River, the Piermont paperboard plant merged with the Gair Co. in 1920 when the latter was a fabricating unit only. The oldest paperboard machine, no. 1, was shut down some time ago, but the two remaining machines with their improvements, and with the advantage of a modern power plant, produce up to 240 tons of paperboard a day.

From time to time, the buildings at the division have been enlarged; notably, in 1914 when space was provided for the manufacture of shipping containers, later moved to Bogota, and in 1926 when the new reinforced concrete factory building was erected to house the paper box machinery moved from Gair's Brooklyn plant. About that same time a storage warehouse, approximately 500 ft. long, was built on the pier side of the plant for materials and finished goods. The folding cartons shop was enlarged to the point where it fabricated practically all the paperboard made by the Piermont mill.

Millions of dollars have been spent in the last few years to make Gair Cartons Div. one of the largest and finest folding carton plants in the country.

Extensive improvements have been made to the paper machines to increase quantity and improve quality. Equipment for the manufacture of machine-coated board, Gaircote, has been installed to provide the finer grades of paperboard suitable for the production of the superquality cartons frequently demanded by customers.

All the operations in the fabricating unit, or box department, have been modernized and improved. Present gluing machines fold and glue cartons with a speed that is beyond measure of the human eye. Two types of new printing presses of particular interest, are those on which a roll of paperboard is fed in one end, printed in several colors, cut and creased, and delivered as finished folding carton blanks. The second is the new battery of sheet-fed gravure presses which makes it possible to adapt one of the oldest forms of fine color printing, heretofore done only on fine grades of paper, to paperboard.

The management of the plant has been under the supervision of the two Williamses and then, in succession, J. L. Andrews, Paul Lang, Floyd C. Costello, Felix F. Doll, Norman F. Greenway (now a vice-president of the parent company, in charge of all folding cartons operations) and Harry Van Decker, who has been in charge since 1939. The paperboard mill superintendents have been John (Jake) Muirhead, Samuel Gregor, George Hancock, Dennis Hogan, and George Oeschle.

The Gair Cartons Div. manufactures paperboard, folding cartons, and such specialties as egg-safety cartons, tufbord, foil-lined or covered cartons, plastic and boxboard combination cartons, cartons printed by gravure. It now employs approximately 1150 people.

For 50 years Gair Cartons Div. has drawn its personnel

m Piermont and nearby towns, which are largely residential; approximately 95% of the staff live within 10 miles of the plant. Fathers and grandfathers of present personnel earned their living in this plant, and the company realizes that its future well-being and growth depend upon the company keeping it such a good place to work, with its good housekeeping, modern methods, sickness and life insurance, hospital and retirement benefits, that it will continue to please its personnel and attract the children and grandchildren of the present workers.

This year 346 employees, or 30%, will have been at the plant over 15 years; 181, 15–25 years; 84, 25–30 years; 61, 30–40 years; 14, 40–50 years; 4, more than 50 years. Two of these, Arthur N. Stowell, watchman, and Stephen J. Fulcer, assistant purchasing agent, have been at the Piermont plant since it started. The other two, Thomas Dalton and John Faust, spent the early part of this half-century at the other Gair Divs.

RAYONIER

Effective labor-management teamwork stemming from a 1946 wage-hour agreement has been responsible for reducing the high frequency rates of industrial accidents in the West Coast pulp and paper industry by 80%. This same teamwork has also been an important factor in the avoidance of at least 6000 disabling injuries in 35 West Coast mills since 1945 and in lower industrial accident insurance rates.

The International Brotherhood of Papermakers and the International Brotherhood of Pulp, Sulphite, and Paper Mill Workers together with the Pacific Coast Association of Pulp and Paper Manufacturers have been holding safety conferences for over a 7-year period in each of the three states, Washington, Oregon, and California, where industrial safety education, accident prevention, and first-aid training are discussed for the over-all guidance of mill safety committees throughout the industry on the Pacific Coast.

The cooperative safety program developed by the conferences, the Rayonier representative said, produced the phenomenal results in accident reduction. "Frequency rates have been brought down from 39 in 1945 to under 8 at the end of September of this year," he said.

During the safety conferences a delegate from each local union in each mill was present, the union paying his travel expenses and personal expenses incident to the two-day meet. Management, which was equally represented, reimbursed the official union delegates for time actually spent at the conference on the basis of eight hours per day up to two days. Attendance has grown from 60 to 200 since the plan was evolved.

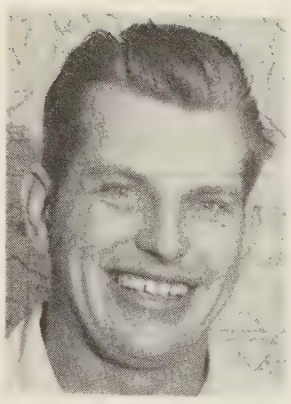
The meetings are usually completely free of mention of grades, safety regulations, or the use of Federal or state legislation as a means to better safety performance. Instead, practical possibilities for accident reduction by more scientific approach through safety education, training, the development of safer work practices, and studies in human reaction and behavior as it affects safety performance are thoroughly discussed.

That education and teamwork between labor and management have paid off is seen in a number of reports from mills showing that their annual accident frequency rates have dropped to 1 and under! At Rayonier management places safety on the same plane of importance that it places quantity and quality of production.

In Washington, the base rate for pulp and paper industrial accident insurance five years ago was 4¢ per workman hour. Today it has been reduced to $1\frac{1}{2}$¢ and there is every indication that the industry will receive a new lower rate next year.

WEYERHAEUSER

Damage from forest fires—perennial destroyer of thousands of acres of woodlands—has been steadily reduced over the past several years through persistent public education, progressive forestry, and logging methods and well-developed fire-prevention and fire-fighting programs.



V. F. McCowan, Weyerhaeuser Timber Co.

One result of this steady, if gradual, decline in the number of acres lost to fire has been to put the limelight on a less spectacular but equally vicious enemy of the forest. Foresters today acknowledge insects as the greatest of the forest's enemies and concede that each year more trees are destroyed by insects than by fire.

Weyerhaeuser Timber Co., long concerned with the insect problem, gave recognition to its seriousness recently by hiring a full-time entomologist, Vaughan F. McCowan.

Mr. McCowan works under the direction of Paul Lauterbach, Weyerhaeuser's research forester, and manager of the firm's forestry research office in Centralia. Spending considerable time in the field, he will study the characteristics and habits of insects found on the company's tree farms in western Washington and Oregon and work cooperatively with the forest insect laboratory of the U. S. Bureau of Entomology, Portland, Ore., to develop effective and practical control measures.

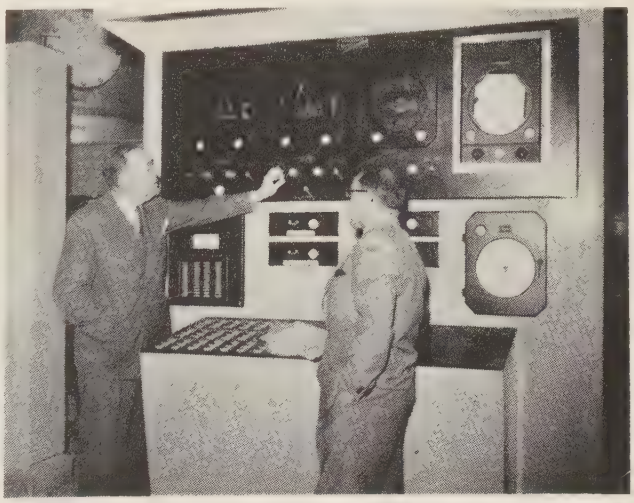
Among the insect enemies McCowan will come to grips with are the Douglas-fir beetle, currently on a rampage of epidemic proportions in southwest Oregon, the spruce budworm, the hemlock looper, the ambrosia beetle, and others.

FLEXOGRAPHIC

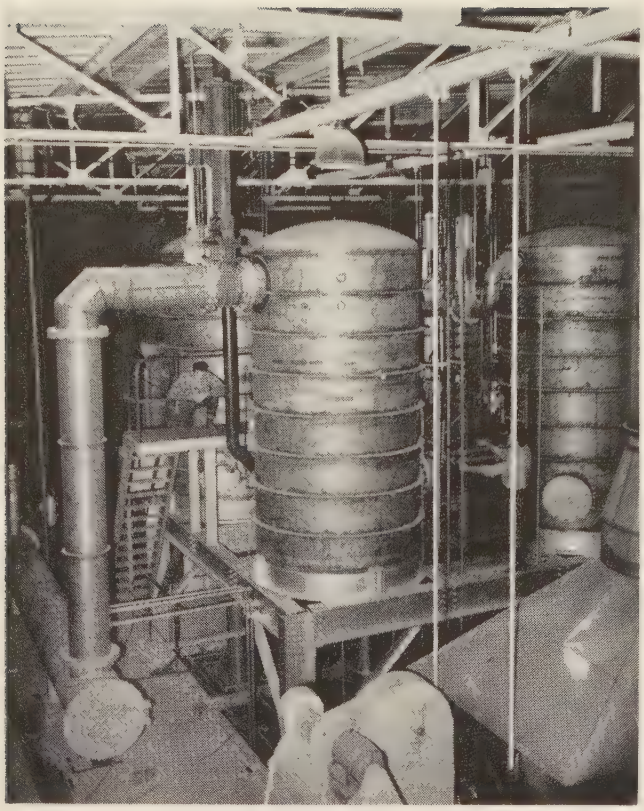
What is this "new" Flexographic printing process? It's a method of rotary letterpress printing that employs flexible rubber plates and rapid-drying fluid inks. And it's not new. Flexographic is just the new name for what formerly was known as the "aniline" printing process, now officially adopted by leading makers of films, foils, papers, printing presses, inks, and plates following a recent industry-wide vote.

RHINELANDER

An evaporating plant equipped with Rosenblad reversible flow triple-effect evaporators with designed capacity to concentrate to 50% solids the bulk of the collected liquor of Rhinelander Paper Co.'s sulphite pulp mill went into operation recently.



Folke Becker, President of Rhinelander Paper Co., starting up the evaporator plant with B. R. Cancell, Vice-President, looking on



Evaporators at the Rhinelander Paper Co. These were made by General American Transportation Corp.

This is the first installation in North America of these special type multiple effect spent sulphite liquor evaporators. The prototypes were developed during World War II by Swedish engineers to avoid calcium scale which forms on hot surfaces of conventional equipment when evaporating sulphite liquor. Rosenblad evaporators permit the operator to switch the steam and liquor from one side to the other of the heat exchanger surface, so that steam may soften and scour off any lime deposits before they have time to harden on the surface as scale.

The plant here was designed to handle the liquor either as it comes from the blowpits or after desugaring in the adjoining torula yeast plant. The evaporator plant, like the yeast plant, belongs to and is operated by Lake States Yeast Corp. This wholly owned subsidiary processes Rhinelander Paper Co.'s spent sulphite liquor for the dual purpose of reducing sulphite pollution of the stream and producing useful by-products.

Rhinelander executives and technical men emphasize that because they are reaching for a higher standard of stream clean-up and by-products reclamation than any known to them in their industry, their installation must still be classed as experimental.

"We do not absolutely know that it will do what we expect of it," said Folke Becker, President of both companies, as he started up the plant at official ceremonies. "Obviously we hope that it will meet our expectations. Otherwise we would not have made so large an investment in it."

More than $400,000 has been invested in this evaporator plant. The yeast plant with which it is teamed cost more than $500,000. Lake States Yeast Corp. thus has close to $1,000,000 worth of plant for its combined objective of stream improvement and by-products production.

The pulp mill's collection system is operated to collect spent sulphite liquor with solids concentration averaging 8½%. Collection to this standard intercepts 65 to 70% of total solids dissolved in pulping More dilute spent liquor is too costly to process and is of necessity released to the stream.

Rhinelander Paper Co. has in recent years modified its sulphite pulp production policies and therefore its operating procedures. Five years ago this sulphite mill manufactured 115 tons of pulp a day, which was close to the total sulphite requirements of the papermaking operations. Meanwhile the company has concentrated increasingly upon making papers requiring greater proportions of sulphite pulp of exceptionally high quality. To produce such pulp has required, among other changes, substantially longer cooking of chips. Output of the sulphite mill has accordingly worked downward to 90 tons per day of extra high quality pulp. The paper mill's requirements of standard quality pulp are obtained from other sources.

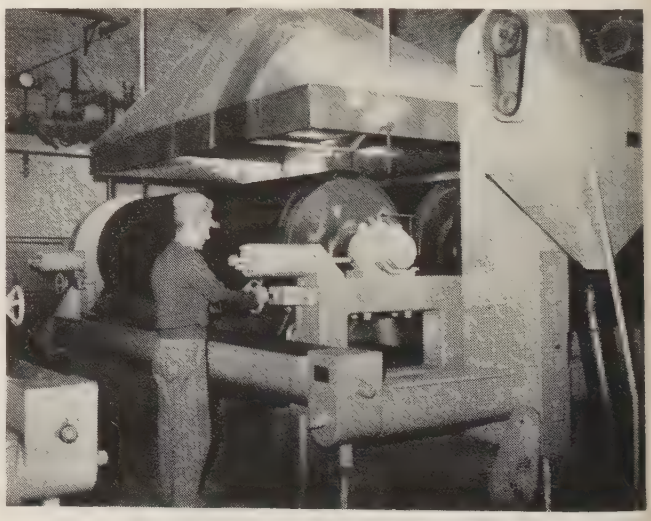
The decrease in sulphite pulp tonnage produced at Rhinelander has had a major effect upon by-products division operations. The torula yeast plant as it was completed in 1948 was designed to process the collective liquor from 60 tons of sulphite pulp operation, which was about one half of the total spent sulphite liquor then being produced. In the interval, operating experience plus equipment modifications have increased the processing capacity of the yeast plant by approximately 50%. Thus there has been achieved a working balance between the supply of sulphite liquor and the yeast plant's processing capacity.

Mathematically the pulp manufacturing and by-products operations of the parent company and subsidiary now are designed to work out as follows (all figures are approximations on dry basis weights):

Operation	*Total tons*
Pulpwood to sulphite mill	180
Sulphite pulp manufactured	90
Solids in sulphite liquor	90
Solids to yeast plant in liquor (65 to 70% collected)	62
Solids to stream in dilute effluent	28
Sugar removed from liquor in yeast plant (19% of total solids)	12
Solids in yeast plant effluent available for evaporators	50

To understand how the evaporators fit into the over-all program of reducing sulphite pollution and recovering by-products, the new process must be viewed in relation to the yeast process which immediately precedes it.

Spent sulphite liquor is pumped from the pulp mill about



Twin-drum driers for processing the lignin

Powdered lignin being bagged for shipment

600 ft. through stainless steel pipe to wooden storage tanks at the yeast plant. Here it is pumped to liquor-conditioning equipment. After cooling it is pumped continuously to the yeast growing tank where it is aerated, agitated, and receives inorganic nutrients. Finished wort continuously bleeds off to centrifugal separators. After washing and recentrifuging, the yeast cream goes to a drum drier.

The clarified desugared liquor is pumped 600 ft. through a surge tank to the evaporating plant. This plant consists essentially of three natural circulation heaters of 1550 sq. ft. each; four vapor bodies; the necessary transfer and condensate points; and, intermediate piping. It is designed to operate between 25 p.s.i.g. and 26 in. of vacuum, and is equipped with multiple jet thermorecompressors to utilize the energy in the 125 p.s.i.g. feed steam without superheating. All equipment including valves and piping is 316 stainless steel. Heaters are 316 extra low-carbon stainless steel. All equipment is operated from a control panel board, excepting a few periodic operations which require manual control, such as switching liquor flow from one side to the other.

The evaporators are designed to evaporate nominally 33,000 lb. of water per hour attaining 3.18 lb. of water evaporated per pound of steam. Since the desugared liquor is at about 7% concentration when it reaches the evaporator, it is necessary to take out by evaporation slightly more than 6 lb. of water from this relatively dilute material to produce 1 lb. of 50% concentrate, which is the objective of the process. Thus it requires about 2 lb. of steam to produce 1 lb. of 50% concentrate. The 50% concentrate is stored in two 10,000-gal. tile tanks.

Heat in the condensate from the heaters (approximately 350°F.) is utilized first in a spiral interheater between low-temperature and high-temperature effects, and finally in a spiral feed preheater before discharging to waste. Vapors from the last effect are condensed in a shell and tube condenser which produces hot water for use in the pulp mill.

From the tile storage tanks previously mentioned the 50% concentrate may be pumped in any of three directions: (1) to driers for production of 94% dry solids; (2) to a dock for loading tank cars or tank trucks; or (3) to the boilerhouse for utilization as fuel.

Drying equipment consists of two 220-sq. ft. twin drum units equipped with variable speed transmission and designed to operate at steam pressures up to 100 p.s.i.g. Dried solids fall off the drums into a screw conveyor and are then elevated to impact mills. Now in powder form, the solids again are elevated to a small storage bin from which they flow by gravity to a screw-type bag filling machine.

The desugared solids, whether in the dry or 50% concentrate form, consist essentially of lignin compounds. The material will be marketed by Lake States Yeast Corp. under the trade name "Toralig." Principal uses are as adhesives, dispersants, and chemical raw materials.

Adhesive uses include not only actual cements and glues but also binders. Linoleum cement, remoistenable adhesive, and paper sizing offer substantial outlets of this general type. Major opportunities as binder loom for foundry cores, fuel briquets, and ore briquets.

Lignin as a dispersant already has found sizable markets for conditioning well-drilling mud, in manufacture of portland cement, in formulating concrete mixes, and in boiler compounds.

As a chemical raw material, lignin from other sources already is in wide use. Particularly publicized is its use as the basic material for vanillin. Lake States Yeast Corp. plans to explore other chemical outlets for this versatile material, with particular emphasis on any advantages inherent in the desugared form. The company already has contracted to sell 20% of the expected output to a chemical manufacturer as raw material from which to derive a food product and pharmaceutical intermediate.

Whatever fraction remains unsold at any time will be piped in 50% concentration to Rhinelander Paper Co.'s boiler room for burning as industrial fuel. This is, however, merely a last-resort use to prevent having to flow sulphite liquor into the river. Rhinelander's combustion engineers have made burning tests and have proved that the material burns satisfactorily when atomized over a coal bed. This method is feasible here since the mill requires far greater quantities of steam than can be produced from the sulphite liquor available.

Although the evaporator plant was built by Lake States Yeast Corp., scientific and engineering knowledge of the Sulphite Pulp Manufacturers' Research League of Appleton was freely employed throughout. Rhinelander and a dozen other Wisconsin mills, along with one Michigan mill, jointly support this organization to do cooperative research in the field of sulphite pollution. All technical information developed in the new Rhinelander plant now or in the future is available to all member mills of the League, and will be used by them in solving their own sulphite pollution problems.

List of Equipment Sources

Heaters and vapor bodies	General American Transportation Corp.
Spiral heat exchangers	American Heat Reclaiming Corp.
Pumps	Worthington Pump & Machinery Corp.
	Blackmer Pump Co.
	Goulds Pumps, Inc.
Piping	Felker Brothers Manufacturing Co.
	Wisconsin River Supply Co.
	General American Transportation Corp.
Valves	Hasco Valve & Machine Co.
	J. B. Astell Co.
	Worthington Pump & Machinery Corp.
	Wisconsin River Supply Co.
	Fisher Governor Co.
Structural steel	Wisconsin Bridge & Iron Co.
Instruments	Taylor Instrument Cos.
	Minneapolis-Honeywell Regulator Co.
	Sparling Meter Co.
Tanks and chests	Chemical Linings, Inc.
	Hauser-Stander Tank Co.
Driers	Buflovak Equipment Div. of Blaw-Knox Co.
Electrical equipment	Westinghouse Electric Corp.
	Cutler-Hammer Manufacturing Co.
Conveying and elevating	Chain Belt Manufacturing Co.
Variable speed transmissions	Reeves Pulley Co.
Bag filling machine	St. Regis Sales Corp.
Atomizing spray burners	Babcock-Wilcox Co.
Fans	Aerovent Fan Co.

Tall Oil

Tall oil, both crude and refined, has been used as a reagent in flotation processes for purifying minerals ever since tall oil became available in commercial quantities. It became important in the flotation of phosphate rock about 20 years ago and thereafter its uses extended to other minerals such as manganese ores and fluorspar. With the depletion of high-grade mineral sources, it may be expected that flotation operations will be extended more and more for separations of low-grade ores. In addition, the principles and techniques developed for the minerals industry are being taken up by other fields having the problem of low-cost, large-scale separations or classifications. The Tall Oil Association, 122 E. 42nd Street, New York 17, N. Y., has just issued Bulletin No. 11 which discusses in full the application of tall oil to flotation processes. Aspects touched upon include flotation principles, collectors, modifiers, frothers, flotation plants, phosphate rock flotation, manganese ore flotation, iron ore flotation, other minerals and other materials.

St. Regis

The St. Regis Paper Co. announces the establishment of five undergraduate scholarships and one graduate scholarship in forestry, effective in the academic year 1953–54.

Three of the undergraduate scholarships will be available in the South, and one each in the Northwest and Northeast. The single graduate scholarship is being offered to first degree holders planning to take graduate work at any accredited school of forestry in the United States.

The scholarships in the South are being provided, one each, at Alabama Polytechnic Institute, University of Florida, and University of Georgia. Each amounts to $800 a year for a period of two years, and will be awarded to an outstanding junior student in forestry at the above-noted schools. They will be chosen by a committee composed of (1) the Regional Forester of the United States Forest Service at Atlanta, Ga.; (2) the respective state forester; and (3) Albert Ernest, vice-president of St. Regis Paper Co. in charge of Southern woods operations.

The scholarships available for undergraduates in the Northwest will be for a period of two years, at $800 a year, for one outstanding junior student in forestry at either the University of Washington or Oregon State College. The award committee for the Northwest will be composed of (1) the Regional Forester, U. S. Forest Service at Portland, Ore.; (2) the Director of the Experiment Station of the Forest Service at Portland, Ore.; and (3) Walter DeLong, Tacoma, Wash., Vice-President of St. Regis Paper Co.

In the Northeast, a single scholarship is being offered to an outstanding junior forestry student chosen from one of the following schools: University of Maine, University of New Hampshire, University of Massachusetts, or New York State College of Forestry. This scholarship, which will also provide $800 for each of two years, will be awarded by a committee composed of (1) the Regional Forester, U. S. Forest Service, Philadelphia, Pa.; (2) the Director of the Forest Experiment Station of the Forest Service at Upper Darby, Pa.; and (3) A. B. Recknagel, Technical Director of Forestry for St. Regis Paper Co.

The announcement points out that the company plans to offer to each of the undergraduate scholarship winners employment during the intervening Summer on some forestry project. Their continuance as recipients during the senior year will depend upon record in the field as well as in school.

The single graduate scholarship in Forestry, valued at $1000 covers only one year and the award winner is expected to direct his studies along lines of value to the pulp and paper industry. The committee to pass on the applicants for the graduate scholarship will be composed of: (1) the Chief Forester of the United States or his delegate; (2) the Assistant Forester Service in Charge of Research; and (3) A. B. Recknagel, Technical Director of Forestry for St. Regis Paper Co.

Inquiries regarding details of awards and specifications for applicants should be addressed to Albert Ernest, St. Regis Paper Co., Atlantic National Bank Building, Jacksonville, Fla., for the Southern schools; to Walter DeLong, St. Regis Paper Co., P.O. Box 1579, Tacoma, Wash., for Northwestern schools; and to A. B. Recknagel, St. Regis Paper Co., 230 Park Ave., New York 17, N. Y., for Northeastern schools.

International Paper

A $400,000 laboratory for basic research work in the development of new pulp and paper grades manufactured from southern forests, was dedicated on November 6 by Erling Riis, Vice-President and General Manager, Southern Kraft Div., International Paper Co., at ceremonies marking its opening.

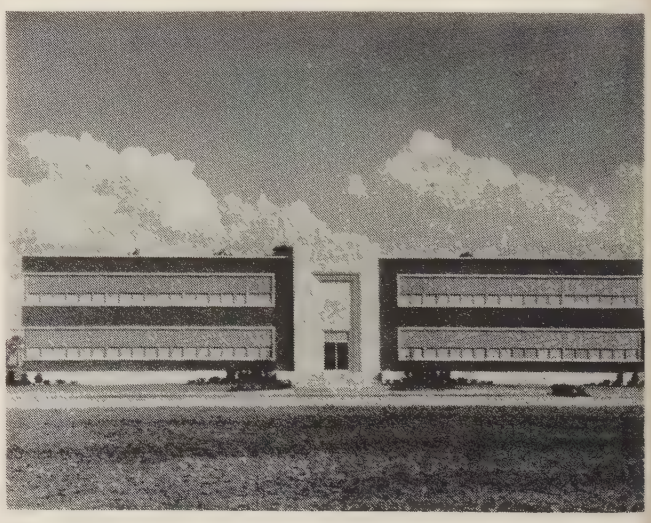
The new building is probably the most modern and completely equipped pulp laboratory in the south, Mr. Riis said. In the laboratory, scientists will be able to duplicate all mill processes on a small scale, greatly facilitating the company's program of research on highly specialized pulp grades.

The Research Dept. is headed by John W. Gilbert, Director of Research, and G. S. Mabrey, Associate Director of Research. Location of the new building adjacent to the division offices at Mobile will permit close coordination of their work with the company's manufacturing and engineering programs. Their staff now includes 40 scientists and technicians.

Three pulp pilot plants and laboratories for chemical analysis, chemical research, and physical research are included in the new building, as well as three controlled humidity rooms and facilities for photographic research and standard pulp and paper testing.

According to Mr. Riis, the Research Dept. at Mobile will concentrate on basic pulp research problems of company-wide scope, or special work which mill laboratories are not equipped to perform. He pointed out that each of the mills in the Southern Kraft Div. will continue to have its own quality control laboratory and staff and will be encouraged to work out its own technical problems, freeing the Mobile organization for broader or more fundamental studies.

The Southern Kraft Div. has been active in research work for many years. Among the achievements of this organization were the first mass production of fourdrinier kraft linerboard from southern pines, the first successful bleaching process for both kraft paper and board in the south, the development of a process for using southern hardwoods to produce the company's Chemfibre corrugating medium, and development



The new research laboratory of the Southern Kraft Div. of the International Paper Co. in Mobile, Ala.

Paper research and development and pulp bleaching area

of the first process for making dissolving pulp by the kraft process from southern hardwoods.

More and more, the work of the laboratory researchers is being coordinated with the work of the forestry and wood procurement departments, Mr. Riis said recently. For example, among the studies currently being carried on are investigations of the effect of wood storage on yield and pulp quality.

"Addition of these new research facilities marks an important step in the development of International Paper Co.'s work in the South." Mr. Riis stated. "With the added opportunities presented for important basic research work, we have every expectation that the leadership our division has exercised in the past will be accelerated in the future.

"Nothing is more important to the growth of the paper industry than a sound research program. With the addition of the new laboratory at Mobile, the Southern Kraft Div. now has a modern private research setup equal or superior to any to be found in the paper industry in the United States.

"Our organization, and the fine research organization of our affiliated Canadian company, Industrial Cellulose Research Ltd., of Hawkesbury, Ont., are prepared to offer buyers the advantages of their outstanding pulp and paper research facilities and personnel."

Pulp Preparation Pilot Area

The pulp preparation pilot area is equipped for making unbleached pulp by any process. A type 316 stainless steel stationary digester with a capacity of about 4 cu. ft. is located in this area. This digester is equipped for direct or indirect cooking and is provided with liquor measuring tanks, turpentine condenser, and recording pressure and temperature instruments. There is a cyclone and a diffuser following the digester and a 30-in. centrifugal is used for thickening after the diffuser. A stainless steel rotary autoclave of 1 cu. ft. capacity is also used for cooking or for other process studies requiring elevated temperatures and pressures. A laboratory Bauer refiner and an Abbé ball mill are provided for use in the preparation of semichemical pulps and also for studying the refining characteristics of other pulps. Equipment is also available for miscellaneous chemical testing, chip classification, and moisture testing.

Pulp Purification Pilot Area

The pulp purification pilot area is located adjacent to the pulp preparation area. This area is equipped with a Valley laboratory flat screen, constant temperature water baths, a 12-in. centrifugal, and earthenware and stainless steel containers for bleaching. Facilities are available for the necessary analytical work and also for the preparation of reagents used in bleaching, such as chlorine water, hypochlorite, chlorine dioxide, and peroxide solutions.

Paper Development Pilot Area

The paper development area is equipped for processing pulp for physical testing and contains a complete set of equipment according to TAPPI T-200 and T-205. This equipment consists of $1^1/_2$-lb. Valley laboratory beater, British sheet machine, a standard disintegrator, press, drying rings, and a Canadian standard freeness tester. Several larger sheet molds are provided for use where larger sheet sizes are required. A two-roll press is provided for studying surface applications and a Noble and Wood rotary drum sheet drier is used for drying sheets at any desired temperature. This area is also equipped for moisture testing and miscellaneous chemical testing.

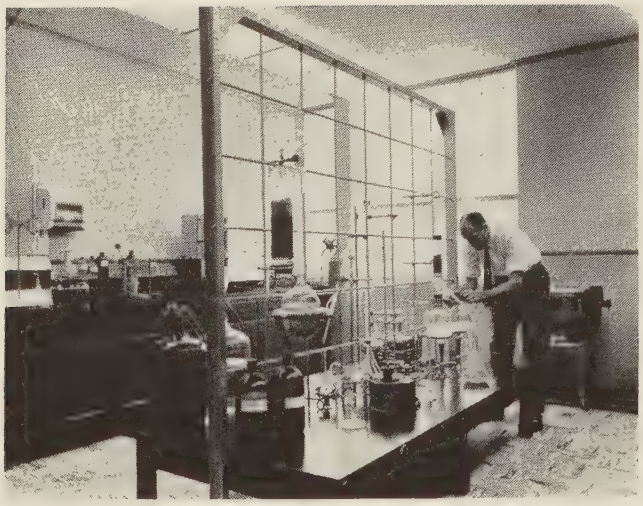
Dissolving Pulp Pilot Area

The dissolving pulp pilot area contains four complete sets of equipment for processing dissolving pulp by the viscose procedure up to spinning. These units are used for studying processing properties of pulps currently being manufactured and also for evaluating experimental pulps made in our own laboratory. One of the four units requires about $^1/_2$ lb. of pulp per batch while the other three require 2 lb. of pulp per batch. The small unit can be used for evaluating any pulp, but is especially useful for evaluating experimental pulps where only a small amount of pulp is available. The three large units can be used for evaluating any pulp and are especially desirable for providing a sufficient quantity of viscose for spinning. Each of the four units consists of the following equipment:

1. *Hydraulic Steeping Press.* The press for the small unit was manufactured in our own shops whereas the presses for the three large units were purchased from M. Hausser Maschinenfabrik Co.
2. *Shredder.* The shredders for all four units were purchased from Baker Perkins. These are water jacketed for maintaining the desired temperature during shredding, and all surfaces coming in contact with the pulp are type 304 stainless steel.
3. *Xanthation Equipment.* This equipment was made in our own shops.
4. *Dissolving Equipment.* This equipment was made in our own shops.
5. *Filtering Equipment.* This equipment was made in our own shops.

A large number of constant temperature water baths are provided in this area for maintaining desired temperature during the various steps in the process. A five-ton Acme

Paper testing laboratory



The chemical research laboratory

water chiller supplies cold water for these baths. Laboratory facilities for viscosity and other tests are provided in this area. No spinning equipment is at present installed, but space has been provided for this at a later date.

Pulp Evaluation Laboratory

This laboratory is equipped for processing pulp for physical testing according to TAPPI T-200 and T-205. This equipment includes a $1^1/_2$-lb. Valley beater, a British sheet machine, a standard disintegrator, a press, drying rings, and a Canadian standard freeness tester. Additional equipment is provided for consistency testing, moisture testing, and for preparing the pulp samples for the beater.

Paper Testing Laboratories

Three laboratories are provided for the physical testing of paper; all three have controlled temperature and humidity. Normally one of the laboratories is maintained at TAPPI standard conditions of 73°F. and 50% relative humidity, one is maintained at 73°F. and 20% relative humidity, and the third is maintained at 73°F. and 75% relative humidity. The normal physical testing of paper is carried on in the room maintained at 73°F. and 50% relative humidity. The wet and dry rooms are used for special investigations where it is desirable to study the behavior of paper in dry and wet atmospheres.

Most of the standard paper testing instruments required for testing any kind of paper or board are available in these laboratories. Also available are several pieces of special equipment such as a single flute crush tester used for studying the quality of corrugating board, an instrument for measuring expansion and contraction of paper, and an instrument for measuring coefficient of friction of paper.

Optical Laboratory

This laboratory contains two Bausch and Lomb microscopes; one is a stereoscopic wide field microscope, while the other is a regular laboratory microscope equipped with an illuminator and polarizing accessories. Additional items in this room include a Bausch and Lomb microprojector, a General Electric reflectance meter, a Bausch and Lomb opacimeter, and a Vancometer. This last instrument is used primarily for studying the surface characteristics of paper and is therefore, very useful in determining the printing characteristics of paper. The laboratory is also equipped for carrying on specialized chemical work related to this optical work. A completely equipped photolab and darkroom is located adjacent to this laboratory.

Analytical Laboratory

This laboratory is equipped with the normal laboratory equipment required for analytical work, such as balances, ovens, distillation equipment, extraction equipment, pH meters, and glassware. In addition, this laboratory also contains special items of equipment such as a Beckman Model DU spectrophotometer with ultraviolet and flame attachments, an oxygen bomb calorimeter, a titrimeter, a Klett-Summerson colorimeter, a laboratory centrifugal, and constant temperature baths capable of maintaining temperatures both above and below room temperature.

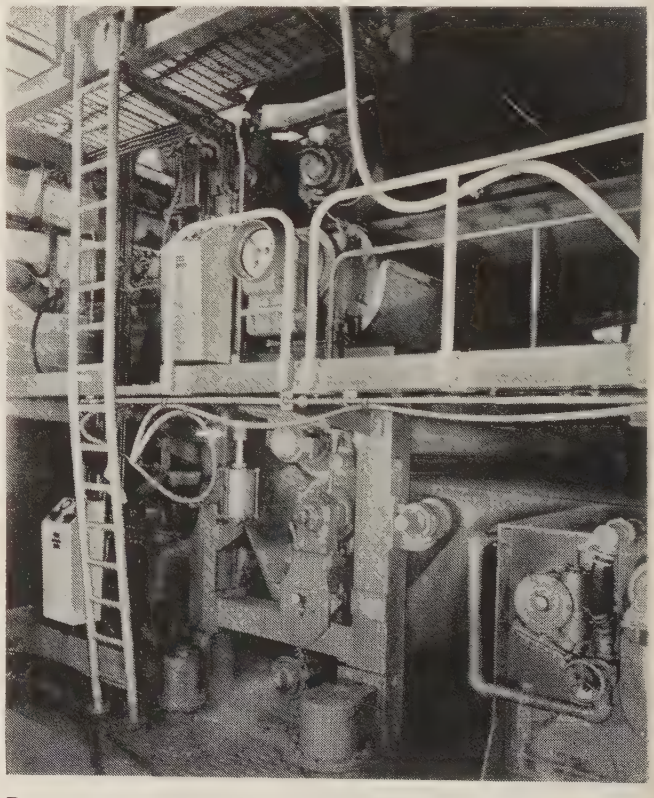
Chemical Laboratories

Three general chemical laboratories are provided for carrying on research and development work. One of these is equipped and used primarily for work related to dissolving pulp, one is used primarily for work related to paper, and the third is used for specialized chemical work.

GIBRALTAR

How can we decrease the time required for this new machinery to pay for itself? An old and familiar question, to be sure, but the Downingtown Manufacturing Co. has given the paper industry a new answer to this old question, and to many others, with the Downingtown load meter. The Gibraltar Corrugated Paper Co. of North Bergen, N. J., asked this same question recently when plans for rebuilding the wet end of their 153-in. cylinder machine were being made. After consulting with Downingtown engineers, it was decided that production could be increased and quality improved by installing Downingtown load meters on the suction extractor, suction drum press, all three primary presses, and both main presses.

It is common knowledge in the paper industry that equal inputs to the loading device on a press—whether air, hydraulic, or weights—do not necessarily give equal outputs at the nip. In fact, with equal weighting on the front and rear of one press it was found, by actual measurement, that there



Downingtown load meters mounted on the suction extractor (upper arrow) and the suction drum press (lower arrow)

was a difference of 2000 lb. between front and rear. The Downingtown load meter has been designed to overcome this shortcoming in press loading and gives an accurate indication of the press loading device output at the point where it counts —namely, the nip.

The Downingtown load meter is a positive, relatively inexpensive, method of measuring press loadings and employs as its sensing unit the strain gage, an electronic device of such uncanny accuracy, ruggedness, and sensitivity that it has been used to measure stresses in planes while in flight, by the steel industry in their stress analysis work, and even by a doctor to measure the pressures in a dog's brain. The accuracy of the strain gage when built into the Baldwin SR-4 load cell and used with a suitable indicating-recording or controlling instrument in the Downingtown load meter can best be realized by stating that for a 300-lb. per in. nip load the strain gage will transmit to the instrument a signal equal to $300 \pm 3/4$ lb.; or with a 500-lb. per in. nip load, $500 \pm 1 1/4$ lb. The extreme accuracy of the load cell comes not from any unnecessary care or expense in the manufacturing of the load cell and its supersensitive nerve, the strain gage, but rather from the inherent properties and characteristics of the strain gage itself.

The Gibraltar load meter installation employs 26 Baldwin SR-4 load cells. These accommodate the suction extractor and six presses with a load cell on each end of the suction extractor and two load cells on each end of the six presses.

Two indicating-recording instruments are used in the Gibraltar load meter installation and both are mounted in the plant's central instrument panel. The instruments provide a visual indication of the loads at all fourteen points together with a permanent, inked, chart record for each point.

The Downingtown load meters at Gibraltar corrugated have been well received by the mill personnel and are more than meeting expectations.

New Texas Mill

The Houston Oil Co. of Texas and Time, Inc., have announced jointly the formation of the East Texas Pulp and Paper Co. which is formed with the intention of building a pulp and paper mill in Evadale, Tex. The plant, to be located in Jasper County, 15 miles north of Beaumont and approximately 90 miles northeast of Houston, will be designed to turn out bleached sulphate pulp and paperboard, with a capacity of approximately 250 tons per day. The new pulp and paper mill will draw a substantial part of its wood supply from lands owned by the Southwestern Settlement & Development Corp., a wholly-owned subsidiary of the Houston Oil Co. It is anticipated that construction on the site will commence this Spring.

The Houston Oil Co. and Time, Inc., own equal shares of the equity interest in the new company. The proposed Board of Directors for East Texas will be as follows: David W. Brumbaugh, Vice-President, Time, Inc.; Harold Decker, President, Houston Oil Co. of Texas; Artemus L. Gates, Director, Time, Inc.; R. A. McDonald, Director, Crown Zellerbach Corp.; A. G. McNeese, Jr., Assistant to President, Houston Oil Co. of Texas; Foster Parker, Treasurer, Houston Oil Co. of Texas; Charles L. Stillman, Executive Vice-President, Time, Inc.; Gurdon Wattles, President, Webster Tobacco Co., and Director, Houston Oil Co. of Texas.

Earliest Papermaking in Ohio

In The December issue of *Ohio Tappi* Ernest F. Barker of the Oxford-Miami Paper Co., West Carrollton, Ohio, has written an interesting review of early papermaking in Ohio:

Robert Fulton steamed from New York to Albany in 32 hours in the first successful steamboat, Napoleon's armies occupied Berlin, Thomas Jefferson was in the White House, and Aaron Burr was tried for treason, when the first ream was produced in Ohio's earliest paper mill. Ohio had been a state for only four years with Chillicothe its first capital. The year was 1807.

On Aug. 1, 1806, an agreement was signed to build a mill near the mouth of the Little Beaver Creek, probably close to Fawcettstown in Columbiana County. This location is now East Liverpool. The signers of the contract were John Coulter of Brook County in Virginia, Jacob Bowman of Brownville, Pa., and John Beaver of George Town, also in Pennsylvania. Called "The Ohio Paper Mills," it probably had two vats producing a good quality of paper, size 13 × 16. The rags were selected and were given no detrimental chemical treatment. This mill used a watermark, a crudely designed eagle, its wings spread and with the inscription "OHIO"; beneath this appeared the initials of three partners, CB&B. Two grist mills and one sawmill were not far from this early paper mill and, since these were doubtlessly equipped with water wheels, it would seem reasonable to assume that the CB&B mill also employed water power. Total employment was about 30 persons. Construction costs for two to four vat mills at that time ranged between $3000 and $8000.

There were ten to twelve printing presses in the state at the time of this mill's opening and with the growth of population stimulated by the recently acquired statehood, other paper mills were soon established. One such mill was built by Frank Howells at Lockport. Converting from a floor mill, he made wrapping, newsprint, and writing; the amount of paper produced was small, the prices high. Around 1810 Howell's daily production was between 100 and 150 lb. Chillicothe saw the foundation of its first mill between 1810 and 1812, at Kinnikinni Creek.

An interesting and very early establishment was the Waldschmidt-Kugler mill also built in 1810 at Milford in Symmes Township in Claremont County. This mill, lying on a bend of the Little Miami River only 16 miles east of Cincinnati, was probably the first in the Miami Valley region. Quite a bit is known about this mill, which is unusual, for records are meager regarding these earliest paper mills. This Milford mill was built by a young German immigrant papermaker, Christian Waldschmidt, who came to the United States in 1786 and practiced his trade first in Pennsylvania. Pioneering spirit urging him West, he constructed the Milford mill with the assistance of John Smith, who became heat vat man and dry loft boss. Construction lasted six months and a contemporary reference mentions the "difficult building of the huge overshot water wheel." The mill was worked mostly by German immigrant workers and papermakers from Germany. One of these was Matthias Kugler who started there with a monthly wage of $8.00. Kugler soon became the mill owner's son-in-law, and special mention is made of this by Dard Hunter.

During the epidemic of 1814, Waldschmidt died, Kugler became master; thereafter the mill was known as Matt Kugler's mill. An early watermark was used here also, consisting of the letters W&C, beneath which appeared the word "MIAMI." Rags were bought for three and four cents a pound, wrapping and writing were made, and production consisted of 100 to 150 lb. a day. Unsubstantiated reports have it that this mill was later mechanized, even to the point of having had an early fourdrinier. This would seem rather doubtful, however, in the light of the fact that the Waldschmidt-Kugler mill was closed in 1850 and the building converted to other uses.

In 1825 there were two power-driven mills in the Miami Valley. We will tell of these and other early mills in a later article in this series about Papermaking History in Ohio.

Forestry Schools

The following institutions are accredited for forestry instruction by the Council of the Society of American Foresters.

Alabama Polytechnic Institute, Dept. of Forestry, Auburn, Ala.
University of California, School of Forestry, Berkeley 4, Calif.
Colorado A. & M. College, School of Forestry and Range Management, Fort Collins, Colo.
Duke University, School of Forestry, Durham, N. C.
University of Florida, School of Forestry, Gainesville, Fla.
University of Georgia, School of Forestry, Athens, Ga.
University of Idaho, School of Forestry, Moscow, Idaho
Iowa State College, Dept. of Forestry, Ames, Iowa
Louisiana State University, School of Forestry, Baton Rouge 3, La.
University of Maine, Dept. of Forestry, Orono, Me.
University of Massachusetts, Dept. of Forestry and Wildlife Management, Amherst, Mass.
Michigan State College, Dept. of Forestry, East Lansing, Mich.
University of Michigan, School of Natural Resources, Ann Arbor, Mich.
University of Minnesota, School of Forestry, St. Paul 1, Minn.
University of Missouri, Dept. of Forestry, Columbia, Mo.
Montana State University, School of Forestry, Missoula, Mont.
State University of New York, College of Forestry, Syracuse, N. Y.
North Carolina State College, School of Forestry, Raleigh, N. C.
Oregon State College, School of Forestry, Corvallis, Ore.
Pennsylvania State College, Dept. of Forestry, State College, Pa.
Purdue University, Dept. of Forestry, Lafayette, Ind.
Utah State Agricultural College, School of Forestry, Range and Wildlife Management, Logan, Utah.
University of Washington, College of Forestry, Seattle 5, Wash.
West Virginia University, Div. of Forestry, Morgantown, W. Va.
Yale University, School of Forestry, New Haven 11, Conn.

The following institutions offer professional and technical curricula in forestry, but do not meet the requirements for accreditation.

Arkansas Agricultural and Mechanical College, Dept. of Forestry, College Heights, Ark.
Stephen F. Austin State College, Dept. of Forestry, Nacogdoches, Tex.
University of Connecticut, Dept. of Forestry and Wildlife Management, Storrs, Conn.
Harvard University, Harvard Forest, Petersham, Mass.
Louisiana Polytechnic Institute, Dept. of Forestry, Huston, La.
Michigan College of Mining and Technology, Dept. of Forestry, Houghton, Mich.
University of New Hampshire, Dept. of Forestry, Durham, N. H.
Oklahoma Agricultural and Mechanical College, Dept. of Forestry, Stillwater, Okla.
University of the South, Forestry Dept., Sewanee, Tenn.
Virginia Polytechnic Institute, Dept. of Biology, Blacksburg, Va.
State College of Washington, Dept. of Forestry and Range Management, Pullman, Wash.

Potlatch

Potlatch Forests, Inc., Lewiston, Idaho, has received a certificate of necessity amounting to 40% of $1,007,000 from the Defense Production Administration for expanding its facilities for making wood pulp from sawmill waste.

Newspapers

While the population of the United States has increased from 106,000,000 in 1920 to 155,000,000 in 1952 the American Newspaper Publishers' Association points out that weekday newspaper circulation in the same period has gone from 28,000,000 to 54,000,000. The population gain was 47% and the gain in circulation was 94%.

Tannin

Importing 70% of the country's tannin requirements and the major portion of our natural wax needs may be unnecessary if the supplies which occur in bark wastes of several trees are tapped.

These useful products have been found in commercial abundance in ponderosa pine and Douglas-fir bark.

Tannin from these sources compares favorably with quebracho tannin for major industrial uses such as leather manufacture and control of viscosity of oil-well drilling needs.

Waxes obtained from tree bark sources, especially Douglas-fir, can be modified for a variety of household and industrial uses. The wax is harder than beeswax, but not as hard as carnauba wax. By chemical treatment, certain of its properties can be made superior to carnauba wax.

Papermaking States

Louisiana is now the no. 1 paper making state, followed by New York, Wisconsin, Michigan, Ohio, Pennsylvania, and Maine.

Washington is far ahead of all other states in total wood pulp production with almost 50% more than its nearest rival, Louisiana. These states are followed by Maine, Florida, Georgia, and Wisconsin.

Newton Falls

The Newton Falls Paper Co., Newton Falls, N. Y., has issued an unusually attractive plastic-covered booklet showing facts and pictures of its "Mill of Tomorrow."

West Virginia Forests

The Northeastern Forest Experiment Station, Upper Darby, Pa., has issued a useful booklet on Forest Statistics of West Virginia.

Finnish Reparations

Finland has paid off her wax reparations. These included $34.9 millions of cellulose and paper products.

Champion

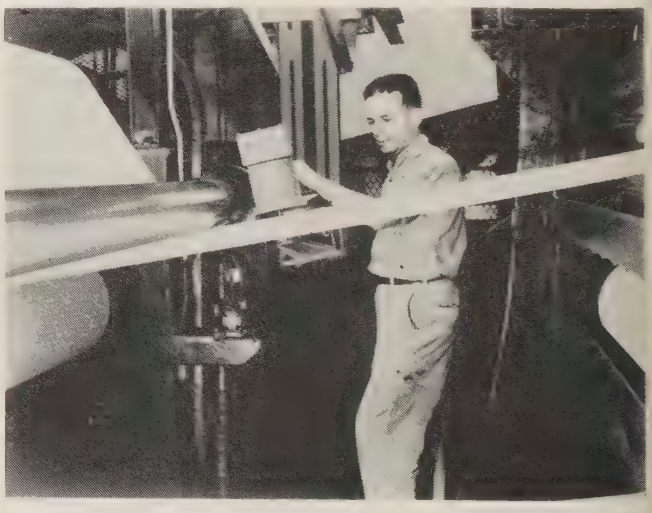
W. R. Crute, Division Manager of the Champion Paper & Fibre Co.'s Texas operations, has been elected Vice-President of the company.

Printing Research

The Second International Conference of Printing Research Institutes will be held in Stockholm and Salen, Sweden, on June 8–13, 1953.

Strathmore

The Strathmore Paper Co., West Springfield, Mass., has installed a Tracerlab BG-1 Absorption Beta Gage on its no. 1



Timothy Babcock of Strathmore Paper Co.'s West Springfield mill checking a Tracerlab Beta Gauge

machine. Use of this gage has enabled Strathmore to hold its sheet weight to less than a 3% variation.

Institute of Paper Chemistry

John E. Stone, who was formerly with the National Re-

search Council in Canada, has joined the staff of the pulping and papermaking section of The Institute of Paper Chemistry, Appleton, Wis.

Three specialists from abroad are currently studying and doing advance research work at the Institute as recipients of educational or travel awards arranged through the Institute of International Education. They include P. Suryanarayana Rao from India, Josef Hlava from Austria, and Charles R. G. Maynard of Scotland.

Sulphur

The U. S. supply of sulphur in all forms now exceeds consumption by 434,000 long tons in 1952 and will exceed it by 363,000 tons in 1953. Supply in 1952 reached 6,524,000 tons against consumption plus exports of 6,090,000 tons. In 1953 the supply will reach 7 million tons against consumption and exports of 6,637,000 tons. Four fifths of the supply is brimstone mined from the Gulf Coast salt dome deposits.

Bolton Award

John W. Bolton & Sons, Inc., Lawrence, Mass., has issued its Fifth Bolton Award Book (1952). It contains the essays of the contest winners: Hugh A. Black, Mead Corp., Chillicothe, Ohio; William H. Chandler, S. D. Warren Co., Cumberland Mills, Me.; C. G. Krancher, Ball Brothers Co., Noblesville, Ind.; Lloyd A. Beck, Mead Corp.; James M. Hill, Jr., Congoleum-Nairn, Inc., Cedarhurst, Md.; Robert E. Windler, Thilmany Pulp & Paper Co., Kaukauna, Wis.; Robert M. Krause, Container Corp. of America, Chicago, Ill.; Kenneth J. Mackenzie, Eastman Kodak Co., Rochester, N. Y.; John O. Markward, S. D. Warren Co.; Alfred O. Mortenson, St. Regis Paper Co., Pensacola, Fla.; Robert L. Parks, Ketchikan Pulp Co., Bellingham, Wash.; Benis P. Wood, Strathmore Paper Co., West Springfield, Mass.; and Charles L. Wright, Kieckhefer Container Co., Delair, N. J.

Morningstar-Nicol

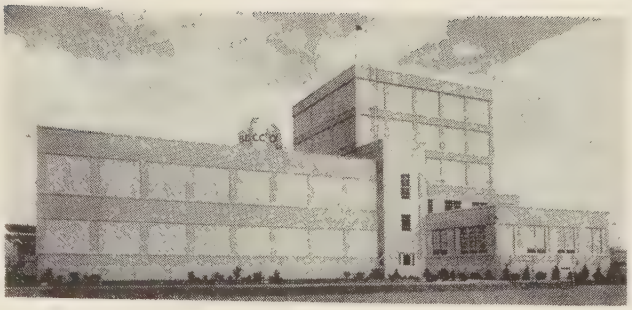
Robert D. McCarron, formerly of the Stein, Hall & Co., has joined the Morningstar, Nicol's Paper Dept. sales staff. Mr. McCarron was formerly Treasurer of the TAPPI Ohio Section.

BECCO

Max E. Bretschger, formerly Vice-President, was elected President of The Buffalo Electro-Chemical Co., Inc., Buffalo, N. Y., succeeding Charles A. Buerk, deceased. Frederick A. Gilbert was elected Vice-President. BECCO is a subsidiary of Food Machinery and Chemical Corp.

BECCO Sales Co., Station B, Buffalo 7, N. Y., has issued a new 11-page bulletin (No. 43) on peroxygen compounds used in treating cellulose and derivatives.

A new BECCO plant is being built in Vancouver, Wash., to manufacture hydrogen peroxide to meet West Coast demand.



The new Becco plant recently constructed in Vancouver, Wash.

Robert D. McCarron, Morningstar, Nicol, Inc.

Max E. Bretschger, Buffalo Electro-Chemical Co., Inc.

Cyanamid

John M. Walsh, Manager of the Paper Chemicals Dept. of the American Cyanamid Co., has announced that his firm has discontinued sale of all grades of casein. For 40 years Cyanamid has been the exclusive United States distributor of casein for the River Platte Dairy Co. of Argentina. Tupman Thurlow Co., Inc., 155 E. 44th Street, New York, N. Y., will take over the distribution. Joseph Brown, who handled casein sales for Cyanamid, has joined Tupman Thurlow Co. in a similar capacity.

Hooker

J. H. Brunn has joined the Hooker Electrochemical Co., Niagara Falls, N. Y., as Director of Research. Dr. Brunn has been with the General Film & Aniline Co. for the past ten years.

Fischer & Porter

William S. Buzzard, Assistant Pulp Mill Superintendent for the West Virginia Pulp & Paper Co., Williamsburg, Pa., has joined the Fischer & Porter Co.'s pulp and paper application staff.

Fischer & Porter Co., Hatboro, Pa., has issued two new bulletins: "Measurement and Control Instruments for the Pulp and Paper Industry" (A-130-1) and "Transmission Systems" (Catalog T-50).

Huber

The New York office of J. M. Huber Co. has been changed from Madison Ave. to 100 Park Ave.

Allis-Chalmers

William E. Buchanen, President of the Appleton Wire Works, has been elected to the Board of Directors of Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Allis-Chalmers has issued two new bulletins: "Texrope Grommet V-Belts" and "Small Vertical Pumps."

Hercules

The Hercules Powder Co., Wilmington, Del., has announced the availability of a new industrial fungicide for paper and other materials. It is called Rosin Amine D Pentachlorphenate. The Monsanto Chemical Co. has been licensed to manufacture the chemical under Hercules patents. It is useful in preventing the rotting of wood. The acceptance of the product has necessitated the construction of new and enlarged Rosin Amine D production facilities at the Hercules' Hattiesburg, Miss., plant.

Arabol

Frank H. McCourt has been appointed Manager of Manufacturing and Sales at the St. Louis, Mo., plant of The Arabol Mfg. Co.

General Dyestuff

The General Dyestuff Corp., 435 Hudson Street, New York 14, N. Y., has issued a new brochure describing the properties and uses of its line of Heliogen colors. Water-dispersible paste brands are suitable for coloring paper in the beater but are not normally used because of a predilection for powder brands by the paper mills.

Minneapolis-Honeywell

James E. Vanderweld has been appointed Industrial Sales Manager of the Portland, Me., office of Minneapolis-Honeywell Regulator Co. and Fred B. Akerson has been named Manager at Portland, Ore.

The Brown Instruments Div., Station 64, Wayne & Windrim Aves., Philadelphia 44, Pa., has issued catalog 1520 on "Electronik Recorders and Instruments."

Hunter Associates

Richard S. Hunter, formerly Chief Operating Engineer with the Henry A. Gardner Laboratory of Bethesda, Md., has announced the formation of a new development, testing, and consulting group devoted exclusively to appearance and related optical properties of materials. The new laboratory is The Hunter Associates Laboratory and is located at 5421 Brier Ridge Road, Falls Church, Va.

Reliance

The Newark, N. J., sales office of The Reliance Electric & Engineering Co. has been moved to 535 High Street. Headquartered at the office are Elwood H. Koontz, F. Raymond Obenchain, and John H. Stevens.

Oldbury

Oldbury Electro-Chemical Co. has begun the construction of its newest addition to its facilities at Columbus, Miss. The plant will make sodium chlorate. Products of the company are sold at 19 Rector Street, New York 6, N. Y.

Cottrell

The Research Corp., Bound Brook, N. J., has issued a new 4-page bulletin, "The Inside Story," giving information regarding the Cottrell electrostatic precipitator for the pulp and paper industry.

Materials Handling

The 5th National Materials Handling Exposition will be held at Convention Hall, Philadelphia, Pa., on May 18–22, 1953. The exposition will be sponsored by The Materials Handling Institute—an exhibition list is obtainable from Banner & Greif, 250 W. 57th Street, New York 19, N. Y.

Lockport Felt

Alan C. Dunham of the Lockport Felt Co., Portland, Ore., was recently honored at Sportsmen's Lodge, Hollywood, Calif., on the occasion of his 25th year of service with the company.

Dicalite

Ruben Zadigan has been appointed District Manager for Western New York by Dicalite Div., The Great Lakes Carbon Corp., and will be located at 975 Fuhrman Blvd., Buffalo, N. Y.

Foxboro

New factory facilities were recently acquired at Dallas, Tex., by The Foxboro Co., Foxboro, Mass., for the assembly of control valves.

Foxboro has issued a new bulletin 447 on "Temperature Recorders."

Nichols

Nichols Engineering and Research Corp. is introducing new methods for conditioning papermaking stocks, involving removing dirt and gases. The methods employed are a research development of Consolidated Paper Corp. Ltd., Three Rivers, P. Q. and will be described in a paper to be presented at the TAPPI Annual Meeting in February.

Sandusky Foundry

The Sandusky Foundry & Machine Co., Sandusky, Ohio, has issued a 4-page bulletin No. 137 on the "Chief Sandusky Shower Pipe."

National Starch

The New England office of National Starch Products, Inc., is now located at 53 Fargo St., Boston 10, Mass. Fred W. Bradley is Division Manager.

Lobdell-United

A final preshipment inspection was made at Lobdell-United Co.'s plant at Wilmington, Del., of its huge roll grinder which is being sent to the first paper mill in Israel.

Group inspecting the Lobdell-United Co.'s roll grinder being sent to Israel

Located at Hadera, a city several miles inland from the Mediterranean at approximately the halfway mark between Haifa and Tel Aviv, the mill will be the first in the Middle East to produce printing and writing paper as well as kraft multiwall bag paper. Owned and operated by the American Israeli Paper Mills, Ltd., and Israeli Corp., it will have an initial annual capacity of approximately 12,000 tons. Exclusive of newsprint and tissue papers, it is estimated the new plant's output will meet 60% of the current over-all annual paper requirements of Israel, which now imports all such products.

The roll grinder built by the Lobdell-United Co. is a vital adjunct to the mill, for it literally will be used to "police" the equipment to insure that the thickness of the paper is uniform and exact to within 0.00025 in.—much finer than that of human hair.

Parsons & Whittemore

Parsons & Whittemore, Inc., and Lyddon & Co. have removed their New York offices to 250 Park Ave., New York 17, N. Y.

Vulcan

Harry W. Haines, Jr., and Martin Fields have recently joined the Vulcan Copper and Supply Co., Cincinnati, Ohio, as Development and Sales Engineers.

Permutit

Coincident with the completion of the Permutit Co.'s completion of its program of doubling its plant capacity at Birmingham, N. J., for the production of ion exchange units contracts have been placed for further expansion, including a new $200,000 pilot plant and laboratory.

Frank Egan

W. H. Wilbert has been appointed to the technical staff of Frank W. Egan Co., Bound Brook, N. J. He will handle plastics extending and processing equipment of polyethylene and similar materials.

Ross Engineering

Employees who have been with the J. O. Ross Engineering ., New York, N. Y., for at least 25 years were presented

The Twenty-Five Year Club of the J. O. Ross Engineering Corp.

with wrist watches by S. W. Fletcher in behalf of the company. An interesting feature of the evening was a period during which each of the members in turn contributed observations reminiscent of their early experiences in the company's employ.

Pandia

A new piece of equipment has been recently placed on the market by Pandia Inc., 122 E. 42nd Street, New York 17, N. Y., which has been named the Pandia discharger. The function of this equipment is to continuously and uniformly discharge pulp at a constant rate from the Chemipulper continuous digester to the atmosphere.

The discharger has gone through its development and mill trials during the last few years and is now available for all Chemipulper continuous digesters, which are capable of producing pulps ranging from high yield semichemical pulp to bisulphite and kraft. All such digesters will be equipped in the future with the Pandia discharger. The discharger will operate satisfactorily with any of the usual cellulosic raw materials used in the paper trade.

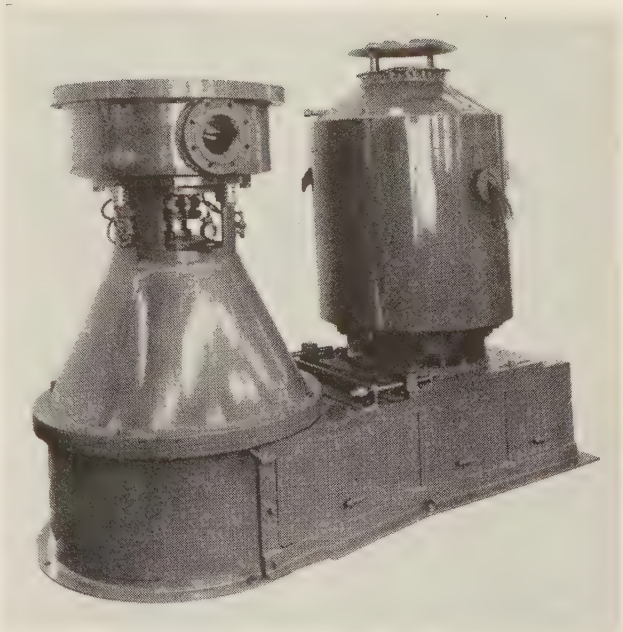
A United States patent has recently been issued for this equipment and has been assigned to Pandia, Inc.

The photo shows a recently built Pandia discharger shortly before shipment to a large integrated pulp and paper mill. The discharger is built for Pandia, Inc., by the National Rubber Machinery Co., Clifton, N. J.

Pandia dischargers, which were originally built and used for experimental and test work, have been shipped to pulp mills for continuous operation. Additional units for larger capacities have been manufactured and shipped and will be in use within the next year.

Mill operation has proved that the discharger uses only a fraction of a horsepower per ton of pulp. The horsepower usage is largely dependent upon the basic raw materials used and the cooking conditions.

The discharger is equipped with one or more continuous flow valves which are adjustable while the Chemipulper is in



The Pandia discharger recently introduced by Pandia, Inc.

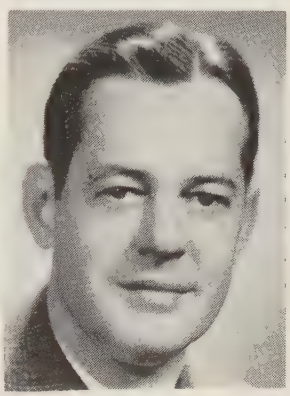
operation; the amount of steam required to blow the stock through the discharge valve is very low. "V" belts from a vertical motor drive the discharger. Roller bearings are used throughout and the unit has its own oil circulation system. The parts of the Pandia discharger which are under pressure are either solid or lined stainless steel. A minimum of floor space is required, even for large pulp tonnages. The Pandia discharger and motor will be mounted on a continuous steel base.

The low operating and maintenance costs for the discharger stem directly from its relatively low speed of rotation, as well as the small amount of work that is required to discharge the stock to the atmosphere.

The discharger will be a component part of the Chemipulper continuous digester for all new installations except that it will not be used to any great degree in the felt industry where the Chemipulper continuous digester is widely used in conjunction with the Asplund defibrater.

Kelco

A. L. Magnuson has been appointed Technical Director of the Paper Dept. of the Kelco Co., Chicago, Ill. Mr. Magnuson joined Kelco in 1939 and has devoted all of his time to technical service to the paper industry. He was one of the pioneers in applying various algins in paper products,



A. L. Magnuson, Kelco Co.

H. D. Wake, manufacturers representative

having been active in the development of their use in surface sizing, paper coating, and adhesives.

BILL GREENE

Herbert D. Wake has joined E. C. Jacobi, Green Bay, Wis., as a representative of Sandy Hill Iron & Brass Works, Hudson Falls, N. Y., and The W. E. Greene Corp., New York, N. Y., representative of The Lodding Engineering Co., Worcester, Mass. Mr. Wake was formerly with Socony-Vacuum Oil Co.

ARIES

R. S. Aries and Associates, 400 Madison Ave., New York 17, N. Y., has issued a new brochure entitled "The Problems of Maintenance Costs," by Jackson D. Leonard.

REMINGTON-RAND

Remington-Rand, Inc., 315 Fourth Ave., New York 10, N. Y., has issued a pamphlet on "Microfilming Service" (BSD-5).

DU PONT

Harry I. Hansen has been appointed Manager of the Detroit District Sales Office of Du Pont's Electrochemicals Dept., succeeding Morell Marlan. Reynolds C. Cochrane will succeed Roland H. Dufault, retired as Manager of the New York District Sales Office.

SEMET-SOLVAY

The Semet-Solvay Div. of the Allied Chemical & Dye Corp. has entered the petrochemical field at Buffalo, N. Y., where it is manufacturing a new material from ethylene, called Alcowax. It is a waxlike material having a melting point of 100°C. It can be used for coating of paper for packages.

OBITUARY

Harry W. Butterworth, Jr.

Harry W. Butterworth, Jr., 62, chairman of the board of H. W. Butterworth & Sons Co., manufacturers of textile finishing machinery and rayon spinning machines, died on Dec. 17, 1952, at his home, 8408 Navajo St., Chestnut Hill, Philadelphia, Pa.

Mr. Butterworth devoted his entire business career to the Butterworth Co., serving as director for 32 years, secretary for 6 years, vice-president for 9 years, and finally president from 1936 to 1952. He retired as president in March of this year and became chairman of the board.

Harry W. Butterworth, Jr.

In World War II, his firm produced gun mounts for the Philadelphia Ordnance District. Mr. Butterworth received a personal citation in 1942 for designing and making his own machine tools rather than waiting an indefinite length of time for priorities. Because of his "ingenious and tireless effort which exemplifies the highest kind of patriotism in war production," Butterworth delivered gun mounts eight months ahead of schedule. Ordnance officials also pointed out his foresight in subcontracting work on nearly 350 of the 510 parts which make up a gun mount, permitting speedier assembly.

During the war, Mr. Butterworth conducted training classes for 250 of his 500 employees, who operated the machine tools he designed for the Ordnance work.

After the war, under his direction the Butterworth firm consolidated manufacturing operations at Bethayres, Pa. They sold their plants in Philadelphia and Providence, R. I., and erected new modern buildings at Bethayres.

Mr. Butterworth graduated from Cornell University in 1911 with a degree in mechanical engineering after taking his preparatory work at Mercersburg Academy.

He was in military service in World War I from 1917 to 1919, retiring as a captain in the ordnance Reserve. Much of this service was in Canada on small arms ammunition problems.

He was president of the Philadelphia Chapter of the Metal Manufacturers Association in 1942–43, having previously served this organization as vice-president, member of the executive committee, and treasurer from 1934 to 1940. He is a member of the American Legion, the Racquet Club, the Philadelphia Cricket Club, the Franklin Institute, the National Association of Manufacturers, and the Edgemere Hunting and Fishing Club, Pike County, Pa.

Survivors include his wife, Beatrice Flood Butterworth, a son, Harry III, of Miami, Fla., a daughter, Mrs. John Findley, of Chestnut Hill; a brother, DeHaven, vice-president of the Butterworth firm; two sisters, Mrs. Lewis C. Dick, Chestnut Hill, Philadelphia, and Mrs. John H. S. Spencer, Wyndmoor, Pa.

LETTERS TO THE EDITOR

Seventh Engineering Conference

To the Editor, *Tappi:*

I would like to take this opportunity to express my thanks to you and your associates in TAPPI, Walter Bloomquist, General Secretary, all committee chairmen, committee secretaries, speakers, and discussion leaders, also the Chicago Sponsoring Committee for the fine work done in connection with the Engineering Division Meeting at Chicago, October 13 to 16.

"Comments received both verbally and in writing would indicate that there was a great deal of satisfaction with the program itself as well as its presentation. I know that everyone concerned will be encouraged to spare no efforts in making next year's meeting a success."

C. J. SIBLER, *General Chairman*
Engineering Division

Methods of Estimating Costs

To the Editor, *Tappi:*

"I am in receipt of the October number of *Tappi* in which a synopsis of the paper given on 'Methods of Estimating Costs for Engineering Projects' was presented. I may say that after reading it I was so interested with the paper as a whole that we have already ordered the book edited by Messrs. Dickson and Littleton that you mention as being published

y the McGraw-Hill Book Co., at a cost of $8.00 a copy. Th s is certainly a big lift to engineers in estimating their i ing and I am sure you deserve to be congratulated on hav- g been able to get information of such wide interest in so rt a period."

A. N. Ball, *Resident Consultant*
E. B. Eddy Co., Hull, P. Q.

Roofing Specifications

o the Editor, *Tappi:*

"ASTM Committee D-8 has sent out a letter ballot to all embers to vote on the desirability of having all roofing ecifications recast on the basis of pounds per 100 square eet instead of pounds per 108 square feet. The latter method specifying is used at present.

"This change in recasting the specifications if carried does change any of the requirements. The tables will show er quantities of material used but it will be in a ratio of 00 : 108. The proposed change is toward simplification of ecifications.

"Those interested in roofing dry felt will note that the roposed specifications will require a minimum weight of 10.0 unds of dry felt per 100 square feet whereas the present re- irement is a minimum weight of 10.8 pounds of dry felt r 108 square feet for those roofing products in which a 0-pound dry felt is used. These two felt usages are equal. he same ratio of weight change will be shown for other lt weights used by the industry.

"I voted in favor of this proposed change and after I learn ae results of this ballot I will write you."

R. S. Vonhazmburg, *Supervisor*
Fiber Product Research
United States Gypsum Co.
Chicago, Ill.

Chip Screen Analyses

o the Editor, *Tappi:*

"Chip screen analyses are common in the literature. As ols for analysis, they are convenient, sufficiently rapid for mediate control, simple enough that nonexpert help can nduct them accurately. These convenient analyses present venues for correlating operating variables, if their data be operly and competently evaluated.

"Evaluation of the data in the reports is often incomplete. eports usually offer a brief summary of chip screen data, ten without comment. Comparison of data is left to in- vidual judgment, aided sometimes by a tabulation, occa- nally by a graph. The usefulness of these methods leaves uch to be desired not because the data are of little value, but ecause the interpretation is difficult. Chip screen data de- rve to be evaluated in a more systematic manner. A cur- ry examination may indicate the presence of gross differ- ces between different data, more often the magnitude and aracter of the differences are not readily apparent.

"We make a chip screen analysis hoping that it will give some useful information about chips. We desire to know, course, something of the average size of chips so that we y gage their coarseness; and we wish to know something out their uniformity. These data are available from chip reen analytical data.

"If we know the size of screen opening that retains 50% by ight of the chips we have a measure of the average size of e chips. We have a measure of fineness that is straight- ward, accurate, and simple; a measure that is independent interpretation, a measure dependent on chips alone. The tio of the sizes of screens retaining, say, 70 and 30% of the weight of the chips give us a measure of the uniformity; again a measure based upon the chips themselves.

"Practically always we find that the size of screens that retain these proportions are not present in our set, and so we must estimate these objectives. A screen analysis does not tell the fractions of each size present, nor does it tell directly much about uniformity. It rather tells us the sum of the fractions that rest between the screens. If we had a great many screens, we could tell more about the distribution of sizes. Even with a few screens, data on the distribution are available if we can interpolate correctly and logically to find the amount that would be entrained on an intermediate screen size.

"There are numerous interpolating expressions that are suitable, and that yield substantially the same results. Of these, $Y = ABn^x$ has certain advantages. In this relation, Y is the fraction retained on a screen opening of size x. A and B are constants whose value depends on the data, and n represents a series of continuing exponents, dependent in numerical value upon the screen analysis data, and whose number is such that there are as many constants as there are screens in the set.

"The advantages of this formula are its adaptability, simplicity, comparability, and its accuracy. It can be adapted to any number of screens, simply by increasing the number of exponents. It is one of the simplest of the expressions that combine these data correctly. It is convenient to use for any given set of screens. For most purposes, it is not even necessary to compute the value of the constants. A slide rule or nomograph is sufficient for most applications of the relationship. Data from different sets of screens can be compared, since the expression is expandible.

"Most important of all, it is accurate, since it is based on all of the screen data. It is an expression that is a summary of cumulative data. In short, it is a mathematical expression of chip sizes and their distribution, the very things that we want to know.

"If we set $x = 50\%$ then we shall find the size of screen that will retain 50% by weight of the chips. Thus we have a measure of the fineness or coarseness of the chips. We may compute the ratio of the sizes of screens retaining, say 70 and 30% (by weight) of the chips, and have a measure of their uniformity.

"Right there we have something that we want to know about chips—their size, and how uniform they are. We have gained this information without a single additional test, just by a simple and logical interpretation of existing data. The method is adaptable to any screen data. Data from previous tests are not rendered obsolete. On the contrary, data from prior tests may be compared and correlated on the same bases as any other data. A comparison of chips from different analyses, even from different nests of screens, can be made logically.

"The expression is derived from chips; it gives us information about chips; it tells us things that we want to know about chips. It provides a way to get some very useful information from the simple, quick, efficient analytical method: the Chip Screen Test."

Guy E. Uhlig
637—19th Ave., Longview, Wash.

TAPPI Services

To the Editor, *Tappi:*

"I wish to compliment you on the services extended to the members of the Technical Association. I know of no other technical society that compares with TAPPI in this respect, especially when the comparison is made in terms of services rendered per dollar paid in dues."

Russell F. Hazelton
Hopewell, Va.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Drying and Ventilating Committee

The Drying and Ventilating Committee luncheon meeting was held at noon, Monday, October 13, in the Morrison Hotel with the following members present:

W. K. Metcalfe, J. O. Ross Engineering Corp.
L. G. Janett, J. O. Ross Engineering Corp.
J. S. Franks, Drew Engineering Co.
R. M. Cook, Midwest-Fulton Machine Co.
G. L. Snyder, Lukenweld, Inc.
A. E. Montgomery, J. O. Ross Engineering Corp.
M. L. Barker, Beckett Paper Co.
C. A. Young, Riegel Paper Corp.

Also present were the two speakers: T. W. Ernst of Trane Co. who was substituting for Mr. Lubinsky, in that a death in the family at the last moment prevented Mr. Lubinsky from attending the meeting. The other speaker present at the luncheon was A. J. Cirrito of Lukens Steel Co.

Also present at the luncheon were the following guests:

A. J. Smith, Midwest-Fulton Machine Co.
H. E. Cluxton, West Carrollton Parchment Co.
P. P. Smith, Continental Paper Co.
R. E. White, Lukenweld, Inc.
W. C. Bloomquist, General Electric Co. (Secretary Engg. Section)

Marshall Barker opened the discussion by introducing the new chairman of the Drying and Ventilating Committee, Curt Young of the Riegel Paper Corp., and turned the meeting over to him after a few remarks on what had been covered by the Drying and Ventilating Committee in past meetings.

The first part of the discussion concerned the drying curves released by TAPPI and it was decided that the curves should be extended particularly on board, kraft, and newsprint, due to the higher operating pressures now being encountered over that submitted at the time the curves were made up. This phase of extending the curves was temporarily left in the hands of A. E. Montgomery of J. O. Ross Engineering Corp., who has promised he will look into the feasibility of getting the above-mentioned curves extended.

Curt Young led the discussion on past subjects as presented by the Drying and Ventilating Committee to the Engineering Section of TAPPI and mentioned that not too much work had been done from the heating and ventilating angle and that nothing had been done on humidity control.

As a suggestion for the members to consider, Mr. Young mentioned the possibility of presenting papers on the following subjects:

1. The Use of Dowtherm for Heating of Drier Rolls.
2. Thermo-Compressor Systems to Increase Production.
3. Use of High Pressure Steam and Driers to Increase Production.
4. Advances and Advantages of Vapor Absorption Systems as Applied to Paper Machines.
5. Finishing Room Humidification Control.
6. Sheet Moisture Indications and Controls.
7. Dewpoint Controls as Applied to Paper Drying.
8. Influence of Sheet Freeness and Its Effect Upon Drying and Production.
9. The Advantage of the Enclosed Machine Drier Section Referring to the Vacuum or Minton Type of Drying.
10. Drying Performance of the Ross Pulp Drier.
11. How the Insurance Inspector Looks at Paper Drying.

In closing the luncheon meeting, it was decided that members of TAPPI would be canvassed for suggestions on talks to be presented at the next meeting so that we could line up and present papers which would prove to be of interest to the largest portion of the attendance group.

The Discussion Session for the Drying and Ventilating Committee was held on the afternoon of October 13, immediately following the presentation of papers by Mr. Ernst of the Trane Co., and Mr. Cirrito of Lukens Steel Co. Approximately 60 persons were in attendance at this Discussion Session which was conducted by Marshall Barker, the outgoing chairman.

Mr. Ernst of Trane Co., who substituted for Mr. Lubinsky, the scheduled speaker, was unable to attend the Discussion Session in that he had made previous train arrangements and had to leave immediately following the presentation of his paper.

The discussions, therefore, centered around the papers of Mr. Cirrito.

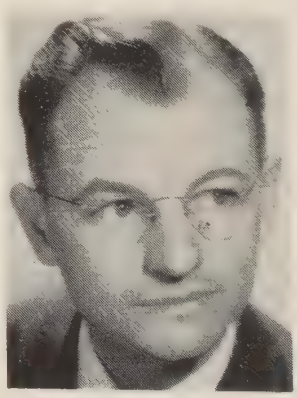
At the start of the meeting, Mr. Barker requested that all persons present who would like to hear certain subjects presented at the next Engineering Conference to so indicate on cards and pass in in order to give us an idea of the type of program the majority would like to hear.

The discussions centering around the paper presented by Mr. Cirrito, which was on the topic of "An Evaluation of Drier Concepts," were particularly with regards to methods of measuring the film thickness in driers and the various factors affecting measurement. These points were covered by Mr. Cirrito in explaining how they had conducted their experiments to measure the film thickness inside the drier shell.

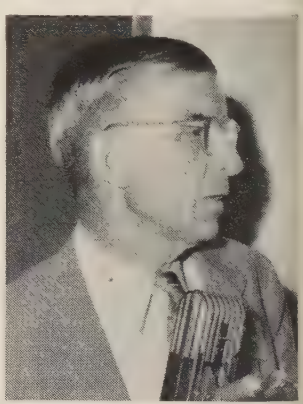
One member wanted to know what effect superheated steam has on the drying rate in that he understood that steam would give up its superheat when it came in contact with the water present inside a drier, but this argument was refuted by Mr. Gough of the Mead Corp., when he mentioned that actual tests have shown that water can be trapped and drained off a steam header having superheated steam indicating that the steam will retain its superheat, even though in surface contact with water.

The request was made that some machine builder present explain what effect the building up of a coating of condensate film inside of a drier after probably four or five years will have on the drying rate. However, apparently no machine builders were present and this question was not answered.

Another member present indicated that he would be interested in receiving data on the effect of getting maximum



C. A. Young, Riegel Paper Corp.; new Chairman of the Drying and Ventilating Committee



M. L. Barker, Beckett Paper Co.; retiring Chairman of the Drying and Ventilating Committee

eat transfer through such methods as reducing end thickness on the drier cylinders which was again referred to the machine builders, but no action taken.

A. E. Montgomery made a few short comments on his recent European trip, and among other things, mentioned that the B.t.u. economy is of more importance to Europeans than tonnage.

At the close of the meeting, there was a short discussion on how to measure surface temperature of driers more accurately than that which can be secured through the use of the Cambridge surface pyrometer. This discussion was rather inconclusive in that no one present could recall of any better method available at the present time other than the Cambridge surface type of pyrometer.

Electrical Engineering Committee

The following members of the Electrical Engineering Committee attended the 1952 Chicago meeting:

F. R. Baker, Westinghouse Electric Corp.
J. ay Chermak, Kalamazoo Vegetable Parchment Co.
N. L. Danforth, St. Regis Paper Co.
T. Foulkes, E. B. Eddy Co.
F. F. Greive, Allis-Chalmers Mfg. Co.
J. L. Grady, Oxford Paper Co.
R. W. Foster, Champion Paper & Fibre Co.
G. W. Knapp, General Electric Co.
A. O. Mortenson, St. Regis Paper Co.
M. J. Osborne, Bowaters Southern Paper Co.
H. J. Perry, *Paper Trade Journal*
R. F. Sorenson, Union Bag & Paper Co.
M. Strain, Continental Paper Co.
J. L. Van Nort, Reliance Electric & Engg. Co.

The general session for the Electrical Engineering Committee was on Wednesday, October 15, from 9 to 10:30 a.m.

Mr. Mortenson presented his report on the Selection of Wire and Cable and Mr. Baker gave his report on the Power Requirements of Press Sections.

In the discussion following Mr. Mortenson's report, Mr. Foulkes mentioned that the report recommends shielded cable above 2000 volts, but the recommended cable specifications do not call for shielding at 2300 volts. Mr. Mortenson stated his specification was made because so many mills do not know how to use shielded cable.

D. F. Langenwalter (General Electric) asked why varnished cambric with a thermoplastic jacket and metallic armor had not been included. Mr. Mortenson replied that it is being used and is mentioned in the report, and that there is no reason why it should not be included.

George B. Gregg (Cincinnati Gas & Electric Co.) asked if gas duct was omitted because the Cable Committee felt its use was improper. Mr. Mortenson stated it was outside of the scope of the cable report, but could be used where there was a dry, clean atmosphere and the flexibility it provides requires its use, such as in the finishing department, machine shop, etc.

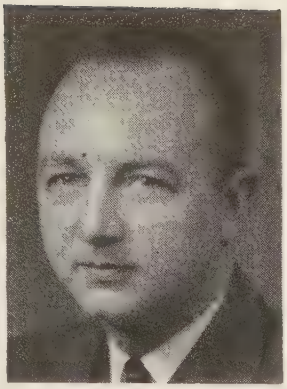
There was no discussion of the report on the Power Requirements of Press Sections.

The round-table meeting of the Electrical Committee was held on Wednesday, October 15, from 3:45 to 5:45 p.m.

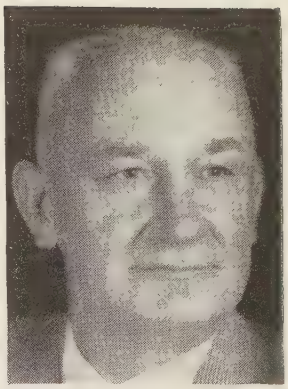
There were approximately 40 people present, 16 of whom were mill representatives.

Mr. Van Nort presented a questionnaire which his subcommittee will use to obtain data on the power requirements of supercalenders. The reaction of the group was very favorable to this and there was little discussion.

Mr. Osborne than discussed his program for obtaining data on the power requirements of chippers and the selection of motor types and ratings. He reviewed briefly the data already obtained from several electrical manufacturers and stated that two of the chipper builders had agreed to cooperate. He is going to send out a questionnaire to the mills and requested the cooperation of the electrical manufacturers



R. W. Foster, Champion Paper & Fibre Co.; Chairman of the Electrical Engineering Committee



A. O. Mortenson, St. Regis Paper Co.; Chairman, Wire and Cable Subcommittee

in assisting the mills with instrumentation. This was agreed to by the motor manufacturers present.

The questionnaire will be designed primarily to get at the energy per cord required to chip. In the discussion which followed, it was decided to modify the questionnaire to ask for the per cent moisture, to estimate an average log diameter corresponding to the highest average experienced over a 4-hr. period, to base all figures on a racked cord of 128 cubic ft. (solids and voids), to request readings for a month. In addition to such energy reading (kw.-hr.), it was decided to consider taking power readings (kw.) using a recorder chart speed of 6 in. per minute.

Mr. Baker, a member of the chipper subcommittee, then presented an excellent paper on the selection of motor ratings for chippers. The reaction to this paper was very good and the considerable discussion which took place had to do largely with estimating the data required to use Mr. Baker's selection formulas.

Mr. Shaad (General Electric) stated that many mills tried to put the large logs through end to end, making it impossible to use an induction motor and stored energy. He also pointed out that additional calculations would be required to give the spacing between logs which were greater than the average diameter, to avoid overheating a given motor rating. Mr. Baker agreed.

Mr. Foulkes said that he felt a compromise between average and maximum diameter should be used in case the spacing between logs was too small.

Mr. Drew (Southland) commented that the average diameter would vary considerably throughout the year and there may be a long run of big ones.

Mr. Knapp stated that the average should be the highest average diameter expected over a 4-hr. period (corresponding to the thermal capacity of the motor). Mr. Baker agreed.

Mr. Drew stated the worst average was very difficult to predict. He had to make a continuing analysis for a month to get an answer when he purchased his last chipper.

Mr. Baker stated that the energy required to chip was independent of diameter. Furthermore, for a given wood room output, the logs of larger than average diameter would have to be properly spaced for substantially constant chipper output.

Mr. Knapp stated that such spacing of the larger diameter logs would not be sufficient to avoid motor overheating because the r.m.s. loading would be greater than the average loading corresponding to constant putput.

Mr. Foulkes commented that the type of cord should be specified, or else weight used instead.

Mr. Osborne replied that many mills don't have weightometers and Mr. Drew said that in Texas the moisture content varies too much. Mr. Drew recommended the use of the "racked cord of 128 cubic feet (solids and voids)" as being most universal. This was generally accepted.

Mr. Grady remarked that in getting the energy requirements, we must not only distinguish between wet and dry, but also frozen and normal wood.

Considerable discussion then took place on the variations in chipper feed rates and chip output to be expected. Messrs. Grady, Osborne, and Baker felt it would be substantially constant. Messrs. Danforth, Drew, and Shaad thought it could vary considerably.

Mr. Drew summed up the situation by suggesting that the formulas be based on constant chipper output, but that they make provision for variations when anticipated. He stated that the mill must know what it wants the chipper to do.

Messrs. Drew, Danforth, and Foster all urged that the formulas be conservative because of past experience with undermotored chippers, and that the need for the project was great.

The committee luncheon was held on Tuesday, October 14, at 12:30 p.m.

The results of the questionnaires sent out by the secretary on Sept. 4, 1952, were reported as follows:

Grounding—Goodrich and Sorenson
Power Requirements Driers—Goodrich, Baker, and Foulkes
Power Requirements Supercalenders—Mortenson and Baker
Selection of Chippers—Mortenson and Baker
A.C. Control—Mortenson
Power Distribution—Baker
Lost Time on Paper Machines—Sorenson
Overload Protection for Motors and Transformers—Cermak
Protecting Motors from Sleeve Bearing Failures—Cermak
Switchgear Modernization—Foulkes
Helper Drives—Foulkes
Tissue Machines—Foulkes

It was agreed that there were so many important projects that all could not be given at the general meetings. Some reports would have to be circulated within the committee and then simply published in *Tappi*.

It was decided to continue work on the supercalender project by sending out the questionnaire. A preliminary report will be given by Mr. Van Nort at the round-table session of the 1953 general meeting.

Mr. Osborne will also present a preliminary report on chippers at the 1953 meeting.

A new project has been undertaken, an engineering analysis of down time on electric sectional drives, under the chairmanship of Mr. Sorenson. A report on this, covering experience at perhaps six mills, will be given at the general session of the 1953 meeting. A uniform bookkeeping system for down time will be developed by Messrs. Grady and Sorenson. It was decided to ask the Steam and Power Committee to do a similar job on lineshaft drives.

It was decided to ask R. H. Kaufmann to write his paper on experience with grounding, which was postponed this year, for publication in *Tappi*.

Mr. Foster is going to get the project on a.c. control started by sending out an outline of what he considers the important points to be in the performance and maintenance of such control, to the several manufacturers. Each will be asked to respond with his story based on the outline.

At the February meeting in New York, it will be decided whether to use the motor control project or the paper on grounding as the second item for the general session of the 1953 meeting.

The project on the power requirements of paper machines will be continued with A. C. Cook (General Electric) investigating drier sections next. His reports will be circulated within the committee, outside, and then published in *Tappi*.

It was decided to make data sheets of the following:

Motor Applications—Sorenson
Selection of Cable—Mortenson
Fourdrinier Power Requirements—Mikelson
Press Section Power Requirements—Baker

The data sheets will be prepared, circulated within the committee (and outside at the discretion of the author), and published.

G. W. Knapp, *Secretary*

Mill Maintenance and Materials Committee

Promptly at 1:15 p.m. following the luncheon the chairman called the meeting to order and advised the committee that by marking and returning the questionnaire, as 12 of the 35 to whom the questionnaire had been sent had done, they had elected by four votes each, the following topics for papers for the 1953 conference: "Application of Moncorrosive Materials" and "Maintenance of Bleaching Equipment" and that they elected by seven votes the following topic for the round-table discussion at the 1953 conference: "Maintenance of Pipe Lines—Internal Cleaning."

The chairman also advised the committee that the topics for future papers which had been returned as part of the questionnaire had been added to the list of future topics and would be submitted when the questionnaire was sent out prior to the 1953 meeting.

The chairman then called for reports from the chairmen of the committees handling the various projects and subcommittee work.

The chairman read the following report from Charles J. Brown, International Nickel Co., chairman of the committee handling Project 342—Copper and Copper Alloys and Monel and Stainless Steels. The monel and stainless steel sections are ready but the work on the copper and copper alloys section has not been completed. It is hoped that the work on copper and copper alloys can be completed shortly.

Henry W. Downs, Jr., Union Screen Plate Co. of Canada, stated that he had been unable to get from the screen manufacturers any data to use in conjunction with Project 376—Screening Capacities of Different Types and Designs of Screen Plates in Various Types of Stock; that he had hoped to secure from one of the most respected screen operators in Canada a large amount of data but that before he could visit with him, he had passed away; that he felt that the only way to get the information was to slowly compile it from questionnaires that will be sent to cooperating mills.

H. F. Parker, New York & Pennsylvania Co., Inc., chairman of the Mill Maintenance & Materials Committee, reported that while there is a vast difference of opinion regarding the possibility of getting any hard and fast methods, he is hopeful of getting some worth-while information relative to Project 377—Grinding Rolls of Various Compositions and Various Purposes.

Richard H. Smith and John Holyoke, Beloit Iron Works, reported that under Project 378—Compilation of a Check List for Mechanical Preventive Maintenance in Pulp and Paper Mills that they had prepared a trial section dealing with paper machine maintenance to see if it was in proper form for TAPPI Data Sheets and that they would discuss the work with Henry J. Perry, chairman, TAPPI Data Sheet Committee.

Chairman Parker stated that the project in its entirety was an enormous undertaking and would result in a maintenance handbook when all sections were completed.

A. M. Cooper, Westinghouse Electric Corp., chairman of the committee handling Project 379—Compilation of a Check List of Electrical Preventive Maintenance in Pulp and Paper Mills reported that the committee had secured the maintenance handbooks of several large electrical apparatus manufacturers and had set up a trial section dealing with motors to see if it was in the proper form for TAPPI Data Sheets; that the material in the trial section was in keeping with the most explicit information in the handbooks on the point being made; that he had talked with Henry J. Perry, chairman, TAPPI Data Sheet Committee, and found the trial

ects were in order; and that additional sections would be coming shortly now that the committee was assured work was in conformity with the Data Sheet requirements. The chairman read the following report from W. W. Henderson, W. W. Henderson & Sons, chairman of committee which has Project 380—Tabulation of Protective Coatings for Use Against Corrosive Conditions in Pulp and Paper Mills in Hand:

Report of Subcommittee on Protective Coatings

Mr. Hubert:

"Following my appointment at the Oct., 1951, Engineering Conference as chairman of your Subcommittee on Protective Coatings I sent during November and December of 1951 a letter to 77 manufacturers of paint and protective coatings whose products are designed to combat corrosion in industry especially the pulp and paper and chemical fields. Of these 77 manufacturers, 29 responded to either the initial request or follow-up letters by submitting to the committee bulletins covering their products. These bulletins detailed each manufacturer's products and their claims for each of the products in the special service for which it was intended. These bulletins have been studied and a tabulation has been made of the products and the manufacturers' claims for each particular product and have been set forth as Section IV of the preliminary report which you have in hand.

"To further clarify the information submitted, a tabulation has been made showing the manufacturers' products together with the manufacturers' application, recommendations which is Section V of the above-mentioned preliminary report.

"I was extremely disappointed by the small number of replies which were received in comparison to the number of manufacturers contacted, however, I feel that this preliminary report is a substantial beginning of what can be a very comprehensive report and urge that the report be turned over to members of the committee so that possibly information may be obtained from the remaining unheard from manufacturers and the report completed."

W. W. Henderson, *Chairman*
Subcommittee on Protective Coatings

The chairman advised the committee that he very greatly appreciated the vast amount of work this committee has accomplished.

B. L. Merriss, Oxford-Miami Paper Co., chairman of the committee in charge of Project 421—Maintenance Costs, advised the committee that he had not secured from the Canadian group the information that he needed to begin his work, but that with the information that had been placed in his hands earlier in the day, he was hopeful of making a long delayed start.

A. I. Sippola, chairman of the subcommittee working with the American Society of Lubrication Engineers, stated that he had had a great deal of difficulty in making a contact with the ASLE but that he believed he had the matter straightened out and that TAPPI would again be able to cooperate with the group that requested its assistance.

C. G. Russell Johnson, Kimberly-Clark Corp., chairman of the subcommittee working with the Inter-Society Corrosion Committee, National Association of Corrosion Engineers, said he had been invited to attend a meeting but had found it impossible to do so.

Richard H. Smith, Beloit Iron Works, in reporting for the chairman of the subcommittee on Maintenance Training Programs advised that this work had progressed very slowly but that he hoped it would gain momentum in the near future.

The chairman stated that the questionnaires returned contained the following requests for new projects.

1. Substitutes for "Critical" Material (Stainless, Copper, Monel, etc.).

H. F. Parker, New York & Pennsylvania Co.; Chairman, Mill Maintenance and Materials Committee

A. P. Schnyder, Ebasco Services Inc.; Chairman, Materials Handline Committee

2. Packing Materials for Various Pulp and Paper Mill Pumps—Standardization.
3. Mastics for Water-Proofing and Beautifying Mill Buildings.

After some discussion it was decided that the chairman request permission to undertake these projects.

The request for new subcommittee work in the questionnaire brought forth the subject: Oil-Resistant Coatings for Machine Lubricant Systems. A committee will be set up to investigate this request.

The chairman thanked the various members making reports and expressed his appreciation for the work that has been accomplished by so many.

H. F. Parker, *Chairman*

Mill Design and Economic Aspects Committee

At the committee luncheon held on October 16 we first discussed a description of the scope of activities of our committee, and it was felt at this meeting that the Association Secretary's explanation of this scope clarified this issue for everyone concerned. I believe that the gist of the explanation was that the Mill Design and Economic Aspects Committee should consider the broad implications as to mill location, construction, arrangement of equipment, service utilities, etc.

It was also decided at this luncheon that our committee for the next session should concentrate its efforts toward having papers delivered on the following two topics:

1. "Fire Protection and Safety in Pulp and Paper Mills." It was felt that the two companies that might be contacted to deliver a talk on this subject are The Mutual Insurance Co., and the Associated Factory Mutual of Boston.

2. "Depreciation of Equipment and Cost of Replacement." This subject was selected because of its broad scope and its appropriateness at this time. It is a matter which must be faced by all pulp and paper mills with increasing importance in the future. One outfit that was recommended for contact, to deliver such a paper, was the Machinery & Allied Products Institute of Chicago.

Following is a brief message from Mr. Packard to the members of the Mill Design and Economic Aspects Committee.

Taipei, Formosa

"I am disappointed not to be able to be present at the Engineering Conference to be held in Chicago next month. When I left Washington in June I confidently believed that my assignment in Formosa would be completed in time to be with you.

"The situation has developed into a most interesting challenge, and someday at a subsequent meeting, I will hope to tell you many of the attractive items I have encountered.

In the meantime let me describe a few points which I feel will be worth while.

"Before I start, I want to express my appreciation in being able to have P. A. Forni act as chairman of the Mill Design and Economic Aspects Committee.

"I can't help but write that the pulp and paper industry on this huge island is far from a small industry as industry goes here. There are 25 privately owned and 5 government controlled mills. The former run from a few handmade sheet plants up to a few three paper machine mills. Most of the paper machines are of the cylinder type, narrow and slow running compared to modern practice.

"Pulp is manufactured from almost everything grown here which has fiber in it. Pine hemlock, bamboo, jute, bagasse, reeds, rice straw, tree bark, banana fiber, cotton rags, old burlap, wastepaper, and burlap are the principal sources of raw materials. Soda, lime, and sulphite cooks are the usual methods employed.

"A variety of papers is manufactured including news, book, writing, bonds, ledgers, wrappings, kraft varieties even up to multiwalled bags themselves for shipping fertilizer and cement. An attempt is now being made to interest the sugar interests (the largest industry in Formosa) to use paper in place of burlap bags which at times cause a spoilage of the raw sugar.

"Two thirds of the pulp and paper manufactured is made by the five mills of the Taiwan Pulp & Paper Corp. This is a Chinese government controlled company until such time shall come when it will be able to carry on independently as a privately owned concern.

"The main purpose of my being sent here was to help this company. Until the collapse of world pulp prices, considerable bagasse pulp was exported. Now, this business has dried up resulting in domestic consumption only. There are four pulp mills using pine and hemlock, bagasse, bamboo, and rice straw, respectively. The capacities go from 80 metric tons down to 3 tons per day. The largest mill, the 80-ton unit is a fairly well laid-out plant which if built today would cost the United States $10,000,000. It has an up-to-date steam generating plant of 110,000 lb./hr. at normal rating at 400 p.s.i. and 200°F. superheat.

"The Mutual Security Agency has been selected by Congress to administer industry in the free nations of Europe, central Africa, and the Far East.

"I hold that Formosa is a frontier of civilization containing about nine million people fortunately separated from the Communists by a sea about 125 miles wide. The Seventh United States Fleet is doing a good job of policing. Yesterday, I was at the southern seaport of Kaohsiung where some of the warships are refuelled. I could see several American supply ships in the harbor.

"We have had several Congressmen and many other officials, both military and diplomatic, visit Taiwan from the United States. It is interesting to hear their several comments about the real progress which has been made.

"I hope that the Engineering Conference will have more than its usual success. As a matter of fact, I always look forward to this meeting annually because the number attending are at a level where you can meet most of those you seek."

P. A. Forni, *Secretary*

Materials Handling Committee

The discussion meeting of the Materials Handling Committee was called for 3:30 p.m. in the Walnut Room of the Morrison Hotel, Chicago, Ill., on Monday, Oct. 13, 1952. The meeting was called to order by A. P. Schnyder of Ebasco Services, Inc., with H. A. Stoess, Jr., of the Fuller Co., acting as secretary *pro tem* in the absence of the secretary, W. R. McNally, of Link-Belt Co.

In addition to the above, the following men were present:

W. A. McKenzie, Simpson Logging Co., Shelton, Wash.
S. D. Wells, Institute of Paper Chemistry, Appleton, Wis.
D. D. Hall, E. B. Eddy Co., Ottawa, Canada
P. W. Bartholomew, Minnesota & Ontario Paper Co., International Falls, Minn.
D. W. Harris, Babcock & Wilcox Co., Seattle, Wash.
J. M. Wilcox, Electric Steel Foundry, Portland, Ore.
C. E. (Dan) Patch, Morton C. Tuttle Co., Boston, Mass.
H. T. Baker, H. K. Ferguson Co., Cleveland, Ohio
H. J. Eklund, D. J. Murray Mfg. Co., Wausau, Wis.
F. L. Califano, Flintkote Co., East Rutherford, N. J.
J. W. Morgan, Celli-Flynn Architects & Engineers, McKeesport, Pa.
J. P. Rich, Improved Paper Machinery Corp., Nashua, N. H.
G. P. Ramsay, West Virginia Pulp & Paper Co., Charleston, S. C.
D. F. Capehart, General Electric Co., Cincinnati, Ohio
C. T. White, Goodyear Tire & Rubber Co., Akron, Ohio
L. L. McGladrey, Wood Conversion Co., Cloquet, Minn.
B. Otis, *Paper Trade Journal*, New York, N. Y.
D. C. Morris, Armstrong Cork Co., Lancaster, Pa.
J. J. Goss, Gaylord Container Corp., Bogalusa, La.
A. N. Ball, E. B. Eddy Co., Hull, P. Q.
W. H. de Montmorency, Pulp & Paper Research Institute of Canada, Montreal, Que.
J. W. Fitzpatrick, Marathon Corp., Menasha, Wis.
W. J. Darmstadt, Babcock & Wilcox Co., New York, N. Y.
L. L. Clark, Link-Belt Co., Chicago, Ill.
W. R. McNally, Link-Belt Co., Chicago, Ill.
M. B. Barkley, Southern Corp., Charleston, S. C.
R. M. Buechler, D. J. Murray Mfg. Co., Wausau, Wis.
C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y.
J. H. Davidson, Minnesota & Ontario Paper Co., Minneapolis, Minn.

Mr. Schnyder requested of the group whether or not there were any questions in regard to Mr. Holekamp's paper which he so ably presented in the morning. There were no questions, and Mr. Schnyder turned the meeting over to W. A. McKenzie, Chief Engineer of the Simpson Logging Co., who led the discussion on "Harvesting and Handling of Smaller Sizes of Pulp Wood from the Forest to the Wood Yard."

Mr. McKenzie stated that this subject had considerable discussion at the Savannah meeting, and there was very little response to the questionnaire and stated that the objectives were to develop some common denominator in the harvesting and handling of small logs including transportation and unloading at the mill yard.

Ten of the men in attendance entered into the discussion, the highlights of which are as follows:

Southern companies are planting trees to insure a perpetual supply of pulpwood—power saws have not reduced costs in comparison to hand cutting, however, a higher type of labor has been attracted with the use of power saws, henceforth a higher production and wages for the wood cutters—one mill used incentive pay to increase output of forest crews—slashing ing units consisting of saws mounted on rubber-tired buggies used in South, but not in North—West Coast is using large size equipment to handle small size timber—4-ft. logs developed in floating down freshlets by Northern mills, 8-ft. logs preferable for handling through mechanical equipment, 4-ft. and 5-ft. lengths difficult to handle by grapple, therefore the development of slings, idea of slings should not be overlooked—a great deal of work is required by management on pulpwood procurement in attaining stable labor—engineers a very important part of management and could do a big part in solving the problem of pulpwood handling—80% of wood produced by small independent farmers east of the Rockies—wire skidding used in Canada, with a cost of approximately $100 for each skid, with this skid using No. 8 solid wire up to one-quarter mile in length, wire fastened to tail tree and winch, 4-ft. wood assembled in slings and skidded downhill on the tree farm—cheaper than wood on the flat, cost $15.70 per cord to the mill—small producer cannot assume obligation of expensive machinery—one mill using 50 cords per day pays the farmers on a weight basis rather than by the cord.

Mr. Schnyder closed the meeting expressing his appreciation to Mr. McKenzie and Mr. Holekamp.

The business luncheon of the committee was held on Tuesday, October 14. Chairman Schnyder opened the meeting with H. A. Stoess, Jr., serving as secretary.

In addition to the above, the following men were present:

H. K. Magee, Link-Belt Co., Milwaukee, Wis.
John Fitzpatrick, Marathon Corp., Menasha, Wis.
D. Hall, E. B. Eddy Co., Ltd., Hull, Que.
C. E. Patch, Morton C. Tuttle Co., Boston, Mass.
E. Drew, Southland Paper Mills, Inc., Lufkin, Tex.
H. de Montmorency, Pulp & Paper Research Institute of Canada, Montreal, Que.
T. White, Goodyear Tire & Rubber Co., Akron, Ohio
McClelland, J. E. Rhoads & Sons, Chicago, Ill.
W. Hemphill, Johns-Manville Sales Corp., New York, N. Y.

Three suggested subjects for papers or discussions were acted upon. Two received favorable consideration, the first being a paper on the use of gasoline versus electric trucks in the paper industry. Mr. Fitzpatrick stated that Mr. Weber of the International Harvester Co. has presented this subject to other organizations, and that Mr. Fitzpatrick thought Mr. Weber would be glad to present it for us. Mr. Fitzpatrick is to contact Mr. Weber.

The second subject to receive favorable consideration was the study of and gathering of comparative costs for the unloading of paper mill chemicals by various methods, pneumatic systems, mechanical systems, and manual labor. A committee consisting of A. P. Schnyder, C. E. Patch, W. McNally, and H. A. Stoess, Jr., was appointed by Chairman Schnyder to prepare a preliminary report for the next Engineering Conference.

Mr. Hemphill suggested that studies be made on wood pulp handling and Mr. Hall suggested as future subjects the pumping of pulp and the use of disposable pallets.

H. A. Stoess, Jr., *Secretary*

Engineering Research and Machine Design Committee

The meeting of the Engineering Research and Machine Design Committee Meeting was called to order at 1:30 p.m., Oct. 13, 1952, by the chairman, John D. Lyall of the Armstrong Cork Co., Lancaster, Pa.

George Clink reported for the Machine Design Data Committee that in the past year no work had been accomplished, because at the last meeting there was considerable discussion about dropping the project of this committee, which is measuring the tension in the wet felt of a cylinder machine. It is the consensus of the committee that this project should be worked on, and Mr. Clink plans activity in the coming year.

George Ehemann reported for the committee on the Investigation of Tension Devices for Paper Web, and commented to the effect that the over-all project was, in his opinion, beyond the scope of the committee and a subject about which a book could be written rather than a paper for presentation at a TAPPI session. It was decided by the committee that the project should consider only the means of measuring paper tension and the actual devices used to control it. The intermediate instrumentation would be left to the ultimate user or designer of such equipment because there are many standard instruments available from the various instrument manufacturers.

L. A. Moore, in his report for the Centralized Control of Stock Systems Subcommittee, reported a similar condition to that of Mr. Ehemann plus the fact that it would be impossible to design a complete system which would apply to any mill, but it would be necessary to take the conditions existing in a given mill and design around those particular problems. It was decided that the object of the activities of this committee would be to present a paper to TAPPI covering the advantages of Centralized Control, illustrating this by showing slides of what had been accomplished in the recent past and where this work had been done. With such a talk it is considered that interest in Centralized Control will be stimulated which, of course, is a step in the right direction.

K. W. Brenner reported for the Committee on the Correlation of Various Types of Plastometers that a TAPPI standard had been prepared and would be presented to the main committee for publication. The TAPPI Standards Committee requested that the sponsoring committee have a vote to approve this standard and the standard was officially approved at the Wednesday meeting.

H. G. Ingraham reported for the Committee, on Methods for Quickly Estimating Costs of Engineering Projects. Considerable work had been done on this project, and two papers obtained and readied for publication in *Tappi*. However, a thorough search of the literature brought forth few facts other than the lack of information available. Mr. Ingraham asked for the expression of the committee as to the value of this project and it was the general consensus of the committee that the work would be continued as any form of data that could be used to determine some reasonable costs on a new project would be of worth-while assistance to the industry in general.

Under the subject of new business, Mr. Curtis presented a motion that the committee take on a more formal form of organization. He presented a very elaborate proposal which was discussed, and for his efforts he was appointed chairman of the committee to consider and present to the February meeting a form of formal organization.

The Wednesday breakfast meeting was attended by 14 people. At this meeting we discussed the procedures and settled the arrangements for the delivering of papers and handling of the discussion period. Unfortunately, the best-laid plans of mice and men get fouled up occasionally due to a long luncheon lecture. The discussion period amounted to about 15 or 20 min. very late in the afternoon.

Subjects being considered for next year are a paper by J. B. Gough on Drier Drainage and a paper by Mr. Ehemann on Paper Tension Devices. L. A. Moore is to review the status of the work on Centralized Stock Control Systems and is to advise us whether or not they could prepare a paper on this project for presentation by next October.

Russel D. Irwin, *Secretary*

Steam and Power Committee

The luncheon committee meeting of the Steam and Power Committee was held on Monday, Oct. 13, 1952. Those present were:

H. R. Arnold
W. M. Wyburn
M. H. Dixon
J. Gottlieb
R. V. Knapp
W. J. Sprau
F. E. Hutton
V. P. Owens
B. M. Turner
W. B. Wilson

Members not attending:

W. H. Hall
M. F. Snauffer
J. E. A. Warner
Edwin Leiss
H. B. Wallace

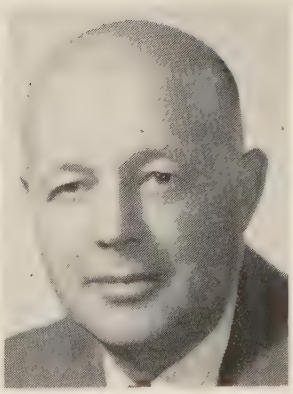
Guests:

C. J. Sibler, Chief Eng., West Virginia Pulp & Paper Co.
M. Strelitz, Continental Paper Co.
R. H. Sogard, Plant Eng., Escanaba Paper Co.
R. G. Macdonald, Ecusta Paper Co.
H. R. Emery, St. Regis Paper Co.
G. B. Gregg, Cincinnati Gas & Elec. Co.

Mr. Arnold opened the meeting and there was a general discussion of a number of topics that had been presented as subjects for the 1953 meeting.

As a result of the discussion, the secretary was instructed

John D. Lyall, Armstrong Cork Co.; Chairman, Engineering Research and Machine Design Committee



W. M. Wyburn, Federal Paper Board Co.; Chairman, Steam and Power Committee

to tabulate the selected topics for a final vote by all members of the committee.

The list of subjects as submitted is as follows and the results of the committee voting are indicated.

Order of Choice	Main Program Topics
B	The Governing of Turbine Generators for the Paper Industry
C	Latest Design of Steam Turbines, Feedwater Heaters, and Surface Condensers for Power Plant and Auxiliary Drives
D	Boiler Fan Selecting Driving, Installation, and Maintenance
A	Functioning of Boiler Code As It Pertains to Paper Industry
	Round-Table Discussion Topics
B	Outdoor Power Plants
A	Interpreting Performance Curves of Single and Double Extraction Turbines and Use of Heat Rates as a Method of Calculating Power Costs
B	Power Plant Maintenance Experience
C	Power Plant Record Keeping

Under the main program those marked "A" and "B" will be the topics chosen for presentation at the 1953 meeting. The speakers will be announced in the near future.

At the close of the luncheon meeting, Mr. Arnold stated that due to the pressure of other activities he wished to resign from the chairmanship of this committee after our 1952 meeting. Mr. Wyburn was appointed to take over this office.

The following names were submitted for membership on the Steam and Power Committee.

H. R. Emery, Plant Engineer, St. Regis Paper Co., Deferiet, N. Y.
R. H. Sogard, Plant Engineer, Escanaba Paper Co., Escanaba, Mich.
R. G. Macdonald, Maintenance Supt., Ecusta Paper Co., Pisgah Forest, N. C.
George B. Gregg, Power Engineer, P.O. Box 960, The Cincinnati Gas & Electric Co., Cincinnati 1, Ohio
N. H. Mailhos, Supt. Power, Brunswick Pulp & Paper Co., Brunswick, Ga.
E. L. Cowan, Power Supt., Gaylord Container Corp., Bogalusa, La.
D. G. Edmiston, Southland Paper Co., Lufkin, Tex.
G. F. Alcorn, Manager Pulp Div., Weyerhaeuser Timber Co., Longview, Wash.
J. E. Mailhos, Chief Engineer, National Container Corp., Jacksonville, Fla.

J. GOTTLIEB, *Secretary*

Container Evaluation and Development Committee

The Container Evaluation and Development Committee was organized from the Container Testing Committee. It was so organized because the Container Committee, originally planned to function in this field, was virtually absorbed by the Corrugating Committee.

The Container Committee as differentiated from the Container Testing Committee was originally organized to include all manufacturers of containers including bags, folding cartons, cellophane, envelopes, corrugated containers, solid fiber containers, cushioning materials, etc.

The Container Testing Committee was reorganized about two years ago last February. The first meeting was held at the Claridge Hotel in April of 1951. At that time an Advisory Committee was established consisting of the following people:

C. H. Krebs, *Chairman*
C. S. Macnair, *Secretary*
H. A. Bergstrom
E. J. Dahill
A. V. Grundy
Arnold Weeks
E. R. Stivers
H. T. Scordas
S. F. Thune
F. A. Wilcox
C. J. Zusi

The scope of the committee was changed from the old scope, "The physical methods of testing heavy containers and container board," to the new scope, "Nomenclature, definition of terms, test methods, performance specifications, and study of the effect of various factors influencing strength and serviceability relating to packaging, including packages, shipping containers and pallets, and the physical methods of testing container boards."

The Advisory Committee consisted of people well grounded in the following fields:

Reinforcing material
Folding paperboard
Paper drums
Paper tubes and canisters
Paper bags
Multiwall bags
Shipping sacks
Corrugated board
Solid fiberboard
Adhesives
The standpoint of the Army
The standpoint of the purchasing agents
The standpoint of the testing laboratories
The standpoint of transportation

The committee now has an identical scope to ASTM Committee D-10. Of course, it differs from D-10, in that it deals in paper products only.

Cooperation between these two groups has been provided for in a special committee known as the Joint TAPPI-ASTM Coordinating Committee. Names of the members are given on a separate sheet, which is attached.

The minutes of the April, 1951, meeting are appended, because it has the scope and the aims of the committee as they were outlined by C. H. Krebs at the time.

Obviously, this was not container testing within the meaning of the phrase, as it applied to our committee. In fact we did not feel that this was an adequate name, nor did we feel that we were adequately represented as a part of the Testing Division. Therefore, we moved to the Converting and Consuming Division and retained the work of the Container Testing Committee under a special subcommittee of our main committee.

The work of this subcommittee has been assigned to laboratory men such as:

W. J. Balster
C. J. Zusi
R. S. Kurtenacker
E. R. Stivers
A. V. Grundy

We have had a good deal of interest in the Committee on Packaging Evaluation and Development, and since it has been formed we have had requests from eight people to become active members of the committee.

Excerpts from the Minutes of the April 17, 1951, Meeting of TAPPI Container Testing Committee and Advisory Board Meeting

The ASTM Committee D-10 Advisory Committee had agreed to the principle of coordination between Committee D-10 and TAPPI's Container Testing Committee. ASTM had selected three men to represent Committee D-10 in the work of coordinating the committees of the two organizations. These three men were Harold Bergstrom, E. R. Rivers, and Albert V. Grundy.

To work in conjunction with this committee TAPPI Container Testing Committee selected H. T. Scordas, F. D. Long, and C. S. Macnair.

All men selected are members of both committees and have been so recognized.

The Advisory Committee of the Container Testing Committee set out to blueprint the work that the committee will set out to do.

One of the first things decided upon was that the Coordinating Committee should screen all proposed standards before they are brought up to the tentative stage. It has been heretofore agreed by the ASTM Committee that this should be the function of the Coordinating Committee as far as ASTM was concerned.

All ASTM standards applicable to conversion to TAPPI will be converted as quickly as possible.

Suitable steps would be taken to request a research appropriation for the development of a movie; the first subject to be a Drop Test. Jim Clark has promised to back the request for TAPPI funds, in accordance with his letter of April which was read to the committee.

It was decided that whenever laboratory research is needed within the scope of the committee this work will be done by a commercial testing laboratory and an appropriation will be requested to cover the expense involved.

Excerpts from the chairman's address to the Advisory Board are to become a part of this report as follows:

"This committee is going to be something different in many respects than any committee that has operated in the past.

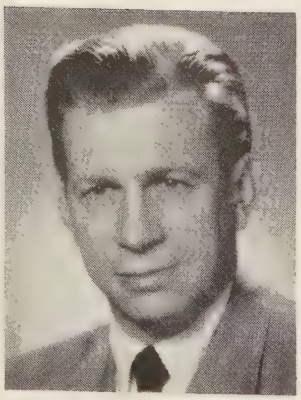
"As we have told most of you individually at the time of the invitation to become an adviser, we intend to operate with an advisory group from which there will also be several subcommittees developed. In some cases members of the advisory group will be subcommittee chairmen, in other cases we will appoint other TAPPI members for chairmanships. The advisory group has been chosen with two aims in mind.

"1. That they are technically inclined in one or more phases of the container business, and they were chosen to represent a definite phase of the container business.

"2. That they are willing to devote a portion of their time to committee work for the good of the various industries.

"In the past, and according to the 1951 *Year Book* the scope of this committee is: 'The physical method of testing heavy container and container boards.' This differentiates this committee from the 'Containers Committee' which is in the Conversion and Consuming Divisions. The scope of the Container Committee is: 'The process of conversion to containers such as folding boxes, cartons, spiral containers, corrugated fiber boxes, etc.'

"For the purposes of coordination with Committee D-10 of ASTM it will be necessary for this committee to operate within the same scope as that in which they operate. It is as follows: 'Scope—Nomenclature, definitions of terms, test methods, performance specifications, and study of the effect of various factors influencing strength and serviceability relating to packaging, including packages, shipping containers and pallets.' It is our intent, and we have so informed Mr. McDonald, that the TAPPI Container Testing Committee will have the same scope as ASTM Committee D-10.



C. H. Krebs, Atlas Box-makers, Inc.; Chairman, Container Evaluation and Development Committee

C. S. Macnair, Acme Steel Co.; Secretary, Container Evaluation and Development Committee

"Temporarily our program lines up as follows with the first objects being:

"1. Definition of terms applicable to containers in packaging.

"2. A concept of packaging: (a) Why pack? (b) Why test? (c) What is rough handling and how can testing procedures be developed to produce and accelerate the effects of rough handling?

"3. Classification of packages with subdivisions of make-up, material, size, density, fragility, and kind of internal support.

"4. Measurements of containers with subdivisions for folding boxes, corrugated, solid fiber, bags, canisters, spiral containers, interior packaging, interior packing, case liners, and partitions.

"5. Standards for sampling.

"6. Standards for score line testing.

"7. Methods for testing manufacturer's joints.

"8. Methods for testing strapping and/or other reinforcing.

"When I review the above subjects I can see months and months of work ahead but each one of these is vitally important to the container business and first of all, it is my own opinion that we should have agreement on terminology and methods of measurements."

C. S. Macnair, *Secretary*

Paper and Packaging Specifications

U. S. GOVERNMENT SPECIFICATIONS

Following is information from W. T. Jones, Paper Section, National Bureau of Standards, on specifications of recent issue:

UU-T-116b Revision, Tape, Paper, Gummed, Water-Resistant; Price, 5 cents.

The revision promulgated Oct. 7, 1952, supersedes Federal Specification UU-T-116 (July 31, 1947) and Interim Federal Specification UU-T-116a (Dec. 29, 1951).

Intended use, transportation description, and packing for domestic shipment have been outlined. Military specifications include a change from JAN-P-140 to MIL-A-140 and marking of shipments has been revised. 94-40645 symbol for exterior, domestic, and export shipment for Air Force purchases and 100-2 standard specification for marking shipments to the Army have been deleted, and in addition to Army special marking required by the contract or order, interior packages and exterior shipping containers shall be marked in accordance with the requirements of Military Standard MIL-STD-129.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

New England

The first meeting of the New England Section in its 1952–53 season was held at the Berkshire Inn, Great Barrington, Mass., on Oct. 10–11, 1952. The theme of the meeting was "Radioisotope Applications." Demonstrations of the use of atomic energy were made by A. L. Burton of Tracerlab, Inc., Boston, Mass. E. E. Dickey, Research Assistant at The Institute of Paper Chemistry, Appleton, presented a paper on "Some Possible Applications of Radioisotopes in the Pulp and Paper Industry." Mr. Dickey's talk follows:

Some Possible Applications of Radioisotopes in the Pulp and Paper Industry

E. E. Dickey

With a single event the atomic age crashed down upon or heads—more gently, to be sure, but with no less realism than for the Japanese.

Overnight we were called upon to gear our thinking to a new force so wonderful, so terrible, so mysterious that most of us are still reeling from the impact. But, slowly, we are replacing a paralyzing fear of the mighty atom with knowledge of its nature and respect for its prodigious power.

One of the most important factors in furthering our acquaintance with the atom has been the program evolved by the Atomic Energy Commission for the nonmilitary utilization of radioisotopes. Many of you are already familiar with some aspects of this program. Researchers in all fields, and particularly in the biological sciences, have put this new tool to work in a rapidly expanding assortment of problems. Industrial laboratories have been alert in evaluating this tool and in giving it work to do.

But in order for us here to meet on a common ground, we need to sketch in the barest of fundamentals upon which the atomic age rests. At the risk of talking down to you, let me first fill in the important concepts about the structure of matter. To be sure, it will be an abridged version.

All matter, you, the chair you sit in, the food you eat, the earth, all are made up—so far as we can tell—from 92 chemical types of atoms—the 92 natural elements. These, in turn, are made up of three main building blocks: electrons, protons, and neutrons. The neutron is known to be a special combination of an electron and a proton, so that these latter two particles of matter in a very real—if not too obvious sense—constitute all the matter of the universe.

Although the proton weighs nearly 2000 times as much as the electron, it is equal in force and opposite in electrical charge to the electron. Thus, these charges attract each other to form electrically neutral combinations.

The simplest combination, one proton and one electron, must be considered carefully because it occurs in two ways: (1) very close association (with an almost unbelievable resistance to separation) to form a neutron, and (2) ordinary type of association (the parts are not difficult to separate) to form a hydrogen atom.

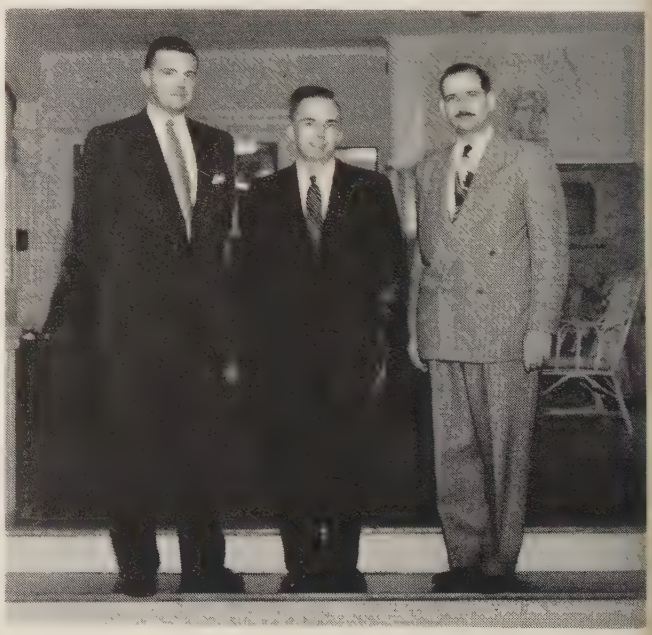
For our purposes, the neutron and the hydrogen atom have the same weight and they are electrically neutral, but their similarity ends at this point. In slightly more technical parlance, the hydrogen atom is composed of a nucleus of one proton and one orbital electron. The term orbital refers to the fact that in all atoms the electrons are arranged on orbits or paths encircling the nucleus which contains the neutrons and protons. Thus, atoms are commonly pictured as miniature solar systems. The next combination of particles consists of one proton and one neutron with one electron to form deuterium or heavy hydrogen. And the third possible combination is of one proton, two neutrons, and one electron to form tritium, a still heavier hydrogen. These, the isotopes of hydrogen, are chemically identical; they are all hydrogen, but their weights are different. The members of such families of atoms are called isotopes, and the radioactive ones are the radioisotopes.

From this point on we must rely on the nuclear scientists to tell us how to correctly combine these particles into all the known atoms.

Tritium is the radioactive isotope of hydrogen, and it decays by the emission of a beta particle. Thus, for reasons which are obscure to all save the atomic scientists, one of the neutrons in tritium divides spontaneously, with explosive violence, the proton stays in the nucleus and the electron is shot out—far beyond the nucleus in spite of and usually beyond the range of electrical attraction. It can't get back in! The remaining group of particles is, of course, positively charged and quickly grabs from some neighbor an electron which always stays outside the nucleus and becomes helium 3, $_2He^3$. The next combinations are the other two isotopes of helium. By properly combining these three particles, all known atoms are readily constructed.

The process of forming all the known (1000+) isotopes of all the known elements is simply one of assembling protons, electrons, and neutrons in the proper way. May we note in passing that the elements are different because of the extranu-

E. E. Dickey, Research Assistant, The Institute of Paper Chemistry, Appleton, Wis.



J. Hourihan and A. L. Burton, Tracerlab, Inc.; and E. E. Dickey, The Institute of Paper Chemistry

ear electrons. There are nearly as many radioisotopes as ere are stable isotopes for the lighter atoms, and for the ier atoms the stable isotopes are frequently outnumbered s, Xe, Ta).

The heaviest natural element is uranium with three isoes, U^{234}, U^{235}, and U^{238} in the relative amounts of 0.0052% 1 lb. in 10 tons; 0.72% or 14 lb. per ton; and 99.27%. atural uranium is, therefore, nearly as pure as Ivory soap, d nearly twice as valuable! In fact we may soon be, if we e not already, on the uranium currency standard!) As ent 92, the large proportion of neutrons over protons is, erefore, a matter of simple arithmetic. Since U^{234} is availde in such small amounts, we shall ignore it. But the nonoplentiful U^{235} is the key to the whole atomic age. It ll grab any neutron which comes near it and the result is which instantly undergoes fission. Fission means that e nucleus divides into two unequal parts, such as $_{53}I^{131}$ and r. Together these elements account for 91 of the 92 pro- and 130 of the 144 neutrons and leave a surplus of one on and 14 neutrons. It is all too obvious that these surs neutrons, if only a few are absorbed by more U^{235}, would a chain of such events. Under optimum conditions, s is an atomic bomb, but when carefully controlled the result self-sustaining chain reaction. With proper amounts of or other atomic fuel arranged in a suitable device, one has atomic pile or nuclear chain reactor.

A nuclear chain reactor is simply a device to control atomic ion so that it proceeds at a slow but useful rate. These ntrolled chain reactions are being used to generate atomic el for our defense program and are being harnessed to use e fantastic quantities of heat which accompany them.

The flow or flux of surplus neutrons in nuclear chain reacs is controlled at a fairly constant level by automatic deces at all times. You have seen pictures of these reactors d are aware that objects and materials of many kinds may placed inside the reactor and irradiated or bombarded with ese surplus neutrons. One example will suffice here. When table compounds of nitrogen, $_7N^{14}$, are placed in the pile, me of the atoms capture neutrons and, simultaneously, it protons. The result is carbon 14. This is a transmutan, and as such it is a link with the remote past. This type change was one of the most powerful driving forces of the hemists in their efforts to make gold from mercury or lead.

S. Klein, Byron Weston Co.; H. W. Knudson, Hollingsrth & Vose Co.; K. P. Geohegan, Howard Paper Mills, Inc.; and P. D. Applegate, Hercules Powder Co.

We know today that failure was their only possible reward. Even today's transmutations include no prospects for making useful quantities of gold from lead or mercury. (Some isotopes of gold are formed from mercury—most from platinum!) But today's transmutations to form isotopes of inestimable value to research and industry would have left the grisly alchemists completely bug-eyed.

Obviously, we have listed only the simplest facts from this vast and rapidly expanding field. "Exploding" neutrons in the nuclei of radio isotopes account for the so-called disintegration of most of the useful radio isotopes.

Such disintegrations result most often in the emission from the nucleus of an electron—the beta particle—with or without gamma rays which are very similar to ordinary x-rays. Both these types and other types of radiation can be detected by means of instruments which are extraordinarily sensitive. Thus, the detection of certain radioisotopes may be 1,000,000 or 100,000,000 times as sensitive as the best method of any other type.

The detection of radiation is accomplished by means of various complicated electronic machines, and by photographic film. But the "work horse" of all radiation instruments is the Geiger-Müller counter usually referred to simply as a Geiger counter. The G-M counter is an amazing device consisting of a closed chamber with a central wire carrying a positive charge, and a metallic wall carrying the negative charge. When an ionizing particle such as a beta particle enters the chamber of the counter, the original ionizing effect is magnified manyfold and an electrical pulse results. A subsequent ionizing event causes another pulse. A properly designed instrument simply adds these pulses or counts from a given source and the sample is thus counted. Results are usually expressed as counts per minute, but other expressions for radioactivity are used. The G-M counter and its auxiliary equipment, under favorable conditions, is one of the most sensitive instruments ever devised. Each count may be regarded as the disintegration of a single atom! Actually, the location of one atom at a time is rarely of any interest, but a few hundreds or thousands of atoms may represent a useful amount of material and would be completely undetectable except for its radioactivity.

The laboratory at the Institute consists of a good hood, lined with strippable paint, table top of stainless steel, a lab bench with stainless steel top, G-M counter and shield, scaler, vault for the storage of the radioisotopes, and a "Cutie pie" laboratory survey meter, and ten iron bricks. Basic instrumentation can be obtained for $2000 to $5000 which is in line with chemical laboratories of many types.

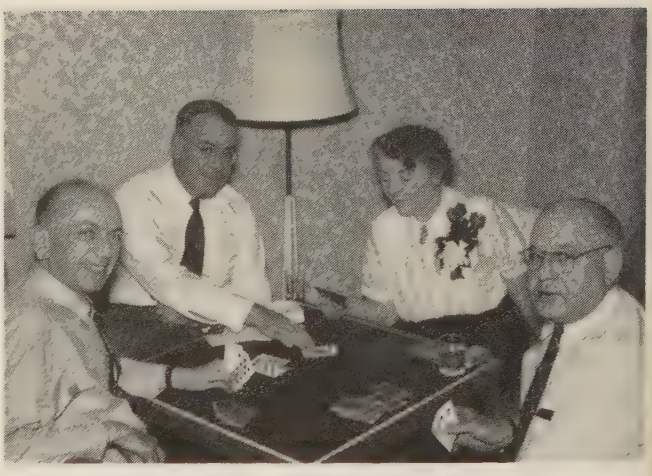
Now that we have the laboratory ready to go, we must state a principle which should guide all those who contemplate any studies by radiochemistry. If the job can be satisfactorily done by any other method you probably won't elect radiochemistry. The reasons are fairly obvious so I shall mention only one: radioisotopes nearly always constitute a greater personnel hazard than other methods.

Exposure to radiation does not leave the victim radioactive. You and I cannot feel, smell, taste, or otherwise detect radiation. We may get a lethal dose and not know it at the time. What happens? Ions form in the tissue just as in the Geiger tube or other matter. These ions do the damage. Thus, methods must be available to survey the radiation and protect personnel.

To a nonpapermaker, at least, the art of papermaking—with emphasis on the art—is one of the most complicated processes ever evolved. A preliminary view of papermaking leaves one with the feeling that much of the operation will never respond to rigorous, scientific treatment. Rather, improvements will come through the ancient cut-and-try principle. However, a closer look at the operation reveals many opportunities for systematic experimentation and with every known tool including radioisotopes.

Applications of radioisotopes are conveniently classified as

Miss Helen Kiely with Harry P. Carruth



Werner Kaufmann, Henry Mellon, Miss Kiely, and Fred Schneider

(1) academic and (2) industrial. Under academic applications one includes the procurement of fundamental knowledge. Such studies are generally carried out in colleges, universities, and research institutes. Industrial applications include nearly all others and consist of studies and research to gain answers to existing practical problems and aid in the development of new processes and products. Both categories of endeavor are essential to the growth of science and industry.

But we shall confine ourselves to practical problems, although many of the examples are fictional and no resemblance to real persons or places is intended.

As of this moment, and offered only as a guess, the greatest usefulness of radioisotopes in the paper industry appears to be in the area of fundamental chemistry. This is based largely on our comparatively gross ignorance—in spite of all the mountains of data—about such questions as: How does lignin react in the sulphite process? What is the sulphur-bearing functional group in thiolignin? What is the chemical nature of the colored bodies in raw pulp? How do certain extraneous components in pine or black cherry inhibit sulphite pulping? The chemistry of pulping, chip penetration, and a host of related questions can possibly be elucidated through the applications of radioisotopes. In fact, these studies are being initiated in laboratories around the world and already the chemical structure of lignin has been aided by work with carbon 14.

A possible troublesome substance which may be retained by fiber is iron. Some color and fading problems are known to be related to its presence in the paper. Studies with radioiron would be easily and rapidly conducted on a small scale in studying the various methods which are designed to remove iron from paper. Radioiron would not be used here as a tracer but as the sensitive agent in an analytical tool. The retention of certain other ions may also be studied.

One of the more glamorous applications for the papermaker is in studies of wear and corrosion.

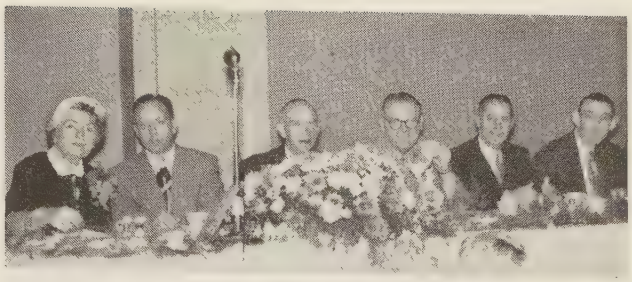
The existing methods for determining wire wear and corrosion may seem somewhat cumbersome. But in general the results are satisfactory. In certain cases, however, particularly corrosion which dissolves some part of the wire, facts may be rapidly and accurately obtained with wire specimens which have been irradiated in the reactor at Oak Ridge. Abrasion of wire by clay suspensions is not difficult and is reasonably rapid. But radiochemical methods would permit the determination of rates of wear and corrosion at greatly increased speeds and with a much greater variety of conditions. The differential erosion, that is, the relative amounts of eroded metal in comparison with the composition of the alloy in question, would be relatively simple to determine for most alloys. Such data would involve the isolation of the several metals from portions of the corroding liquor by any of the usual methods. The relative activities of each separated metallic element would be readily compared with the relative activities available in the original alloy. Actually it might appear that the manufacturers of metal products should perform such corrosion studies since they are the uncontested experts on the metal products they produce. But you are the uncontested experts in corroding the equipment which you buy and may profitably conduct some studies of corrosion which are vital to your processes.

To my knowledge, no attempt has yet been made to design an experiment which could possibly tell us the rate of wear or erosion of metal parts of machines where paper is in contact with them. Such experiments could be built around metal parts that had been made radioactive in a nuclear reactor. For example, the wear of paper on metal rolls would then be possible by comparing the used paper with unused paper as a control.

Al Bachmann presenting the testimonial book to Miss Kiely

Miss Kiely acknowledging the ovation of the group

...re Drewsen, Mayor of Northampton, Miss Lena Kelly, ...erican Writing Paper Corp., R. G. Macdonald, TAPPI, ... Carruth, Miss Helen U. Kiely and H. W. Knudson, Hollingsworth & Vose Co.



Miss Kiely, H. W. Knudson, K. P. Geohegan, Howard Paper Mills, Inc., A. E. Bachmann, Missisquoi Corp., E. C. Reid, American Writing Paper Corp., and A. E. Sherwood, Sutherland Paper Co.

...e possible retention of phenylmercuric acetate by paper ... the subsequent transfer from paper to foods has been ...ed and disputed, and has evaded the efforts of analytical ...ists to get the truth at low levels of the agent. Mercury ...s an especially useful isotope for radiochemical studies of ... problem. It has both beta and gamma radiation of rel ...ly low energy, a convenient half-life of 43 days, and is ...ly available at $1.00 per mc. A project is under way at ... present time to get some data as to the extent of adsorp... of PMA by paper.

...me of the most attractive studies would involve isotopes ... oxygen, nitrogen, magnesium, aluminum, and silicon, but ...se elements have no useful radioisotopes. They can be ...died only by means of stable isotopes but the techniques ... quite different, not especially versatile or rapid, and re...ire such expensive equipment that few laboratories can ...lize them.

It seems to us that the most efficient means of initiating an ...vestigation at the Institute involving radioisotopes is for ... co-operator to submit a statement of the problem as it ex...s. The staff of the Institute may then examine the com...nents of the problem, decide on the approach to be made ...d assign personnel from the department which seems best ...ted to do the work.

It is obvious that we, at the moment, have no long list of ...plications. These will come from the industry, first as prob...ms, then as possible solutions.

The following comparison may be a little exaggerated or in...propriate, but the field of radiochemistry would appear to ... now in the age of crystal sets. For radio this came 25 to ... years ago. Look at us now! We have reforested most of ...r cities with television antennas! However, neither the ...per industry nor any other established enterprise can be ...volutionized with radioisotopes. These agents are merely ...other tool which will take its place along with pH meters, ...ectrophotometers, and all the rest of our technical aids.

Although our experience at the Institute with radioisotopes ... just beginning, we hope to at least keep pace with the de... opment of the tool. Also, we are convinced that the ...eatest usefulness of radioisotopes to the industry will come ...m applications made on problems which the industry itself ...omits.

But not all problems of papermakers involve attempts to ...lize radioisotopes in research and analysis. At least one ...oblem involves the accidental presence of radioisotopes in ...per.

Probably the most subtle of all problems of the atomic age ...hat of radioactive impurities in paper and other materials ...ving the manufacturers of photographic films. A repre...tative of Eastman Kodak writes us that radium paint and ...ion particles from atom bomb tests have already given ...m some trouble. One example cited was as follows: ...out 15 years ago there was a considerable increase in the ... of radium paint for painting the dials of instruments for ...craft. The workers who painted the dials commonly cleaned their brushes on bits of wastepaper which eventually found its way into chipboard. By 1941 the contamination had accumulated to such an extent that no chipboard made from wastepaper could be used for packing their x-ray film. Similar trouble came from the A-bomb test in Nevada. A committee of the National Association of Photographic Manufacturers is watching this problem very closely. I need hardly mention that the careless use of radioisotopes in laboratories and factories could do tremendous harm to this great industry. These problems, however, would shrink to microscopic size in comparison to those which would attend a so-called atomic war—even though all the bombs fell 10,000 miles away.

In closing, since I have no personal, financial report for you, may I ramble on to the end of these comments in somewhat philosophical vein? Man has been shaken—clear back to his primate ancestors—by the cataclysmic onset of the atomic age. But he is slowly recovering his consciousness and is just beginning to harness this cosmic force as a research tool and finally as a source of power. In my humble station I cannot predict, I am not qualified to predict, the possible developments of applied atomic energy. But I haven't the slightest doubt that radioisotopes and atomic energy will help you to make more and better paper.

New England

Helen U. Kiely Night

The meeting of the New England Section held at the Roger Smith Hotel, Holyoke, Mass., on Friday, November 21, was designated as "Helen U. Kiely Night." It turned out to be a magnificent testimonial to Miss Kiely who devoted so much time and effort to organizing and building up the Section over its years of existence.

The meeting was featured by an attendance of well over 200 members of the Section and friends of Helen. Letters and telegrams from well wishers were received from all parts of the United States and Canada.

These expressions of esteem, together with a bound volume containing signatures and comments from more than 300 individuals, were presented to Miss Kiely. In addition she was presented with a substantial travel certificate and a life membership in the Technical Association.

The committee in charge of arrangements for the meeting consisted of Henry L. Mellern and Paul Applegate of the Hercules Powder Co., C. I. Horton of R. T. Vanderbilt Co., and Lester B. Crouse of Penick & Ford, Ltd.

Albert E. Bachmann, Vice-President of the Missisquoi Corp., Sheldon Springs, Vt., presided as toastmaster. In his able and witty manner he recounted his memories of the time when he served as a chemist under the direction of Miss Kiely, Chief Chemist of the American Writing Paper Co. He read several of the large batch of telegrams and letters received from men prominent in the pulp and paper industry.

He then presented the speakers at the head table who have been long-time friends of Miss Kiely. These included Pierre Drewsen, Mayor of Northampton, Mass., and formerly Chief Chemist of Hinde & Dauch Paper Co. in Sandusky, Ohio (Miss Kiely resides in Northampton); R. G. Macdonald, Secretary-Treasurer of the Technical Association; Harry Carruth, retired, who employed Miss Kiely at the American Writing Paper Co. as the first woman chemist employed by

A. E. Bachmann, with H. W. Knudson on the left presents a travel certificate to Miss Kiely. R. G. Macdonald and P. D. Applegate are on the right

the paper industry; Kenneth P. Geohegan of the Howard Paper Mills, Dayton, Ohio, and President of TAPPI; Edward C. Reid, President of The American Writing Paper Co.; A. E. Sherwood, Vice-President of the Sutherland Paper Co., Kalamazoo, Mich; Miss Lena Kelly, Assistant Chief Chemist of the American Writing Paper Co., Walter Cassidy, Sorg Paper Co., Middletown, Ohio; and William Anderson, of the Stevens Paper Mills, Inc., Windsor Locks, Conn.

Several of the speakers were Miss Kiely's protégés. Mr. Bachmann commented on her ability to train young chemists, many of whom now hold high positions in the paper industry and mentioned that the very large attendance and the testimonial letters reflected the large number of people who have been helped by Miss Kiely, and the sincere expression of appreciation felt by the allied industry because of her untiring cooperation with them in working out their problems of serving the paper industry.

Following the enthusiastic and friendly remarks by the head-table group, Mr. Bachmann and H. W. Knudson, of the Hollingsworth & Vose Co., East Walpole, Mass., and chairman of the New England Section, presented the book of testimonials, the travel certificate, and life membership certificate to Miss Kiely, after which she responded graciously and with undisguised emotion. Since the occasion was somewhat of a surprise especially in regard to its magnitude, Miss Kiely showed more signs of being overwhelmed—not too much—but more than somewhat.

Delaware Valley

The Delaware Valley Section of TAPPI met at 6:30 p.m. on Oct. 23, 1952. About 85 members and guests were in attendance. Harold Brill of Du Pont, presiding as chairman, opened the meeting by calling to the attention of the members the pending loss to the Section of Mr. Erspamer who will be leaving this area to take up a new position in St. Helen, Ore.

Since there was no old or new business to be brought up, Mr. Brill called upon Program Chairman Frank Lovegren of the P. H. Glatfelter Co. to introduce the speaker of the evening.

Mr. Lovegren introduced Gordon Wheeler of the Lithographic Technical Foundation, Chicago, Ill.

Measurement of Paper Properties Important in Offset Printing

Gordon C. Wheeler

PRINTING operations that are directly affected by the properties of the paper may be classified into three groups: (1) feeding, (2) pulling the impression, and (3) delivery and bindery operations. These operations will be discussed in this order.

FEEDING

To insure uninterrupted feeding of sheets on the press, paper should be flat. Wavy edges, tight edges, or a curl can all be detected by visual observation of the pile of paper. The tendency of the paper to curl or change size cannot be measured in this way. From the time that the paper is manufactured to the time that it is finally printed, changes frequently occur in the paper's moisture content. The hygroexpansivity of the paper is therefore of considerable importance.

A test for hygroexpansivity of paper (TAPPI Standard T 447 m-45) is available. However, it gives only the over-all expansivity. Since differences in physical size of the wire and felt sides of the sheet would tend to promote curl it would be desirable to be able to measure the hygroexpansivity of each side independently.

There is another important factor that determines the tendency of paper to lose flatness. This is its water vapor permeability, both perpendicular to the sheet surface and from the edge into a pile of sheets. While water vapor is traveling from the edge of the sheet toward the center, or from the center outward, a gradient exists. This means that tight or wavy edges will continue to exist until the moisture content of the sheets is uniform through the pile. The rate at which water vapor will penetrate will determine the time required for the paper to reach approximate uniformity. Also, after printing, the side of the sheet that was in contact with the blanket will contain more water than the other side. Until the difference in moisture content is removed, the sheets will have a strong tendency to curl.

TAPPI Standard T 448 m-49 offers a test for the water vapor permeability of paper. This test, however, measures permeability only in the direction that is perpendicular to the surface. It would help a great deal if we also had some way of measuring parallel permeability through a pile of sheets.

There is another type of curl, called structural curl. This results when stresses incorporated in the sheet during manufacture are later released. Structural curl has yet to be measured quantitatively.

For trouble-free feeding on the press, the paper must have square and straight edges and the sheets must be uniform in size and caliper. All of these properties can be measured with well-known techniques.

PULLING THE IMPRESSION

A field of paper testing in which a great deal of activity is evident is the measurement of its printability. The properties that contribute to printability can be divided roughly into four groups: (1) physical strength, (2) chemical properties, (3) ink receptivity and permeability, and (4) printing smoothness. These four factors will now be discussed briefly.

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rength Properties

When the inked blanket is separated from the paper a force exerted on the paper surface that tends to rupture it. The pick test is quite widely used to measure the ability of the paper to withstand this force. However, recent work has shown that it is not reliable for comparing papers of widely differing weights. It is probably satisfactory for the comparison of papers having the same weight and surface texture unless thermoplastic materials are present in the coating.

A number of dynamic pick testers have been developed. All of them attempt to duplicate the printing operation to some degree. Some print at an adjustable, but uniform, speed. Others incorporate an accelerating device so that the speed at which picking occurs can be determined from one sample. Newtonian liquids and printing inks are both used. It appears that, in the near future, we will be able to test for pick resistance with assurance of good correlation to actual press experience.

Some of the fibers on the surface of paper are not very well bonded to each other or to the body of the sheet. Some are held down only at one end. This leaves fuzz or lint standing up. These fibers tend to be pulled off by tacky ink. They accumulate in the inking system and necessitate frequent wash-ups.

If the sheet is bent around a short radius and observed under a magnifier, these loosely bonded fibers can be seen. Papers can be compared by this means. Of course, the observer's judgment is very important since the test is not quantitative.

A quantitative test has been suggested. It consists of shaving the surface of the paper with a sharp blade and measuring the quantity of material removed. This test may not tell the whole story. The printer is concerned not only with the fibers that stand up, but also with those that lie flat and which will also be pulled off by the ink. A reliable quantitative test is needed to measure this paper property.

If an attempt is made to print paper on which the coating has been poorly insolubilized, the coating will tend to transfer to the blanket. If the material transferred is abrasive, plate wear will be excessive.

Some idea of the water resistance of the coating can be obtained by rubbing it gently with water and then transferring the water to a piece of black paper. When dry, the transferred coating appears white. This test again is only comparative. It depends on the operator's judgment. Also, it does not duplicate printing conditions very closely.

Another strength property should be included. This is the tensile strength that the paper needs to resist web tension or the pull of the grippers. Because of the high speed of modern printing operations, the paper can go from an unstressed to a stressed condition and then back again in a very short period of time. For a true evaluation of paper with regard to its future performance on the press, one should test it at similar loading rates.

Chemical Properties

Any soluble materials in the paper tend to be leached out by the water on the blanket. These materials then get back to the plate and into the inking and dampening systems. Surface-active or wetting agents will promote emulsification of the ink in the water. Fountain solutions having high pH values may also cause this to happen. Since water is deposited on the areas of the paper not being covered with ink, an over-all tint results when the ink and water emulsify.

To test for the presence of wetting agents, scrape some coating off the sheet and shake it up in a little water. If the foam persists for more than 3 or 4 min., there is reason to suspect the presence of these materials. Naturally, this test fails when the wetting agent doesn't produce much foam.

pH is important not only because a high pH promotes emulsification, but also because a very acid paper will retard ink drying. It may even etch the printing plate and shorten its life. Methods are available for measuring the pH of the water extract of uncoated paper or of the coating from coated paper. Probably of more importance than H-ion concentration alone is the quantity of potentially reactive alkali or acid, and the nature of the anion when alkali, in the extract. Also, it is questionable whether the extraction method now used is very closely related to the extraction that takes place on the press when the paper is in contact with moisture for only a few thousandths of a second.

Ink Receptivity and Permeability

There are roughly three stages of ink vehicle absorption that take place in printing. The first is that which occurs during the first 0.005 sec. that the paper is in contact with the ink. It determines, to some extent, the way in which the ink is transferred. Nonuniform ink receptivity of paper during this period can cause mottled solids.

The second stage occurs during a short period of time after the sheet has been printed. If the absorption of the ink vehicle is slow, the ink will offset to the backs of succeeding sheets in the delivery pile. If properly matched to a particular paper, the ink normally sets to a condition where offsetting does not occur during this time.

The third stage of absorption occurs while the ink film is hardening. During this stage, excessive absorption can cause the ink surface to lose its gloss. If the ink film hardens too slowly, chalking can occur on coated paper. (Chalking results when so much vehicle is removed from the pigment that the pigment is left "high and dry" and is not bound to the paper surface.)

The final test for the ink receptivity of paper is its behavior on the press. Mottling will occur on some papers when solids are printed under certain conditions—generally when a light color is being used. No method for measuring this tendency to produce a mottled print has been publicized.

Even though uneven absorption during the printing period is not yet subject to quantitative measurement, progress is being made in the over-all measurement of ink receptivity. One method is as follows. A drop of ink is placed on an incline above a sheet of paper to be tested. A cylinder is then rolled down this incline over the sheet. Then, by measuring the size and shape of the pattern produced by the ink drop, a combination of the paper's surface smoothness and absorbency is probably measured.

Many methods for testing absorbency during the second two periods have been advanced. They all involve some technique for measuring the rate of penetration of an oil or ink into the paper. The techniques include: (1) measurement of the time required for an oil or ink film of known thickness to lose its gloss when applied to the paper surface, (2) measurement of the change in light reflectance from the reverse side of the sheet after the oil or ink has been applied, and (3) use of the K and N testing ink.

The K and N testing ink consists of a white pigment dispersed in a nondrying oil carrying an oil-soluble dye. The ink is spread on the paper surface, allowed to stand a known length of time, and then wiped off. The intensity of the color left in the paper is said to indicate the amount of oil absorbed by the paper from the ink.

Absorption of ink vehicle after printing involves a limited amount of vehicle, filtration of this vehicle through the pigment next to the paper surface, and penetration of this vehicle into the sheet. Because of the nonhomogeneity of paper, especially coated paper, most absorption tests are questionable. This is particularly true of any absorption test in which penetration is to a much greater depth than actually occurs in the printing process. Thus, any of the above techniques may not give satisfactory results if the technique involves a greater depth of oil penetration than normally occurs when the paper is printed.

Two phenomena are influenced by the smoothness of the surface of the paper. One involves completeness of contact of the printing form or blanket with the paper. The other is the print quality obtainable.

It is possible to get over-all printing contact between the offset blanket and papers that are too rough to print satisfactorily by letterpress. For this reason, the problems of printing smoothness are considerably different for the two processes.

The Chapman smoothness tester is being tried as a means of measuring printing smoothness for letterpress work. In it, the paper is pressed against a glass prism at approximately printing pressure. This pressure is necessary to allow for the cushioning effect or flattening of the paper surface under the printing form. The fraction of incident light that is reflected from the glass-paper surface is dependent on the amount of paper surface not in optical contact with the glass. Attempts are now being made to simulate the conformability of the ink surface. If this problem is worked out, this test method looks very promising for evaluating letterpress papers. Some modification would probably be necessary to make it suitable for offset papers.

Other methods in use involve measurements of the air leakage between the surface of the sheet and a flat surface under a pressure differential. Various methods using a number of different conditions of pressure and area of contact between paper and flat surface have been advocated. The apparent disadvantage of this method of smoothness measurement is that the air can travel through the body of the sheet as well as across its surface.

Of more importance to the lithographer is the influence of smoothness on the appearance of the printed material. The smoother the ink surface, the purer the color since diffuse reflections are reduced.

DELIVERY AND BINDERY

Some of the requirements of paper involved in the delivery of the printed sheets on the press and with finishing and bindery operations have already been discussed.

The tendency of paper to curl was discussed under feeding. Under ink receptivity and permeability, we discussed the influence of ink absorption on its setting to prevent offsetting. Under chemical properties, the influence of pH on ink drying was covered.

Excessive curl can cause severe difficulties in sheet delivery. It can also greatly increase costs during cutting, folding, and other finishing operations.

Poor ink drying can delay bindery operations and possibly even cause the job to be rejected because of late delivery.

At present, there are few reliable tests for measuring the properties of paper that are important in lithographic printing. Progress is being made in developing suitable testing procedures and correlating them with printing practice and results.

IRVING GRUNTFEST (Rohm and Haas Co.): Would you discuss the correlation between the wax pick test and actual press picking?

MR. WHEELER: Correlations have been made between the wax pick test and offset press picking. In general, they are good when the selection of papers is limited to those having uniform caliper and surface characteristics. In other words, when comparing papers all of the same thickness and surface, correlation is good. The wax test can be very misleading when used otherwise. This is probably because dynamic loading takes place on the press while the wax test is almost a static load test.

MR. GRUNTFEST: How about the reliability of the wax test on latex coatings?

MR. WHEELER: From our experience with only about 36 papers, of which about one third contained latex, the latex does not influence the test. Of course, in this series, only small quantities of latex were present. The results might have been different if the coatings contained more latex.

LOUIS GEORGEVITS (Titanium Pigments Corp.): Wouldn't the use of all latex for binding the coating eliminate pick difficulties?

MR. WHEELER: I see no reason to believe that that would necessarily be so. Also, the latex would probably be too expensive for printing paper.

THAGE DAHLGREN (Pioneer Chemical Works): Does latex give a better ink-receptive surface?

MR. WHEELER: I don't know. The Lithographic Technical Foundation is not now testing coating formulation, and I do not have any direct comparison under controlled conditions. It would seem to me that other variables are more important.

MR. DAHLGREN: It gives better results on machine-coated papers. In the case of chalking that you mentioned, is this a flat ink?

MR. WHEELER: Chalking is the condition that occurs when the vehicle is removed from the ink film leaving the powdery ink pigment on the surface of the paper. This pigment can then be wiped off. Naturally, if chalking occurs, the ink surface has a flat, instead of a gloss, surface.

MR. DAHLGREN: Are the surface-active agents mentioned, wetting agents?

MR. WHEELER: Yes.

A. E. MAY: Do wet-strength additives lead to printing troubles?

MR. WHEELER: I understand that, in order for the melamine wet-strength papers to cure, they have to be made acid. This acidity, if excessive, may etch plates or hinder drying. However, this does not necessarily mean that they will cause trouble.

MR. MAY: Does the printer get satisfactory absorption on wet-strength papers?

MR. WHEELER: Wet-strength papers can be made absorptive, so I see no reason why he shouldn't.

C. S. MAXWELL (American Cyanamid Co.): Is there an advantage in having controlled absorption?

MR. WHEELER: Absorption is important in getting the ink to set to prevent offset.

HAROLD BRILL (E. I. du Pont de Nemours & Co.): How does ink formulation affect the printing?

MR. WHEELER: Ink formulation is the method of alleviating nearly all troubles. If formulation will not correct the problem, then the paper is investigated. Actually, the problem is twofold. The tendency is toward glossier inks which are more tacky. Reduction of the ink to prevent pick reduces its gloss, so paper must have resistance to picking.

MR. DAHLGREN: Does impression pressure relate to pick?

MR. WHEELER: Yes, picking is increased by increased pressure. In the case where pressure across the press was not uniform due to improper packing, the picking occurred first on the side having the highest impression pressure. A certain amount of pressure is needed to get a good print, so there is a minimum feasible pressure.

QUESTION: Is it economical to use a press for testing?

MR. WHEELER: That is the only method of testing for certain paper properties. It is uneconomical and difficult to control when compared to specialized testing instruments.

S. M. ROTONDO (Container Corp. of America): How do you test for water resistance?

MR. WHEELER: A drop of water is placed on the coated paper to be tested and lightly rubbed. It is then transferred to a piece of black paper. When dry, the transferred material appears white. This is a comparative test only, and does not indicate how abrasive the material is. Abrasive filler or coating can cause premature plate failure and loss of press time resulting in greatly increased cost.

MR. GEORGEVITS: What tests are used for abrasiveness of coating?

MR. WHEELER: I don't know what tests are used. Actually, the quantity of material removed determines whether abrasiveness is important.

P. L. HAGGARTY (George La Monte and Son): How much does acid damage the plate; what is the pH limit?

MR. WHEELER: It would be difficult to put limits on pH since probably the buffering capacity of the extract is also important.

G. K. BOGER, JR. (Paper Products Manufacturing Co.): Does the principle of a colloidal interface, the shift from absorption to adsorption enter here?

MR. WHEELER: The ink film thickness is from $^1/_4$ to $^1/_2$ thousandth of an inch. I doubt if adsorption forces apply to a layer more than a few molecules thick.

R. W. FORREST (Downingtown Paper Co.): What factors in the paper influence the mottling effect?

MR. WHEELER: Probably calendering causes thicker areas of the paper to become less absorptive than the thinner areas resulting in variation in ink receptivity.

NELSON ARIGO (P. H. Glatfelter Co.): Are you familiar with the Optak Process as used in Philadelphia by Edward Stern & Co.?

MR. WHEELER: No.

PHILIP HERSHEY (P. H. Glatfelter Co.): In connection with machines for testing offset, what tack graded ink is considered

necessary for paper to withstand? Also, is there only the 1 to 8, or are other tackier inks available?

MR. WHEELER: The tack-graded ink that will pick a particular paper depends on the testing instrument used. I don't know of any ink tackier than 8.

MR. HERSHEY: How about the Waldron pick tester?

MR. WHEELER: We have made some preliminary tests attempting to correlate it to press. I think it may require some adjustment or the development of more complete experimental procedure in using it to get good correlation.

MR. GEORGEVITS: How could the K and N ink test be correlated with printability?

MR. WHEELER: One method would be to take a series of inks graded by formulation as to their gloss properties. These inks could then be used on a series of papers to rank the papers. A correlation could be made between this ranking and the K and N ink test.

Southeastern

The Southeastern Section of the Technical Association of the Pulp and Paper Industry met at the George Washington Hotel in Jacksonville on Nov. 21 and 22, 1952. A dinner was held at 6:30 p.m., Friday evening, followed by a program of excellent papers. On Saturday morning the members in attendance were taken through the Fernandina mill of Rayonier, Inc.

A new feature of the meeting was the social hour imediately preceding the meeting, with a special refreshment center set up in the registration area. Registration and the social hour started at 6, dinner was served at 7, and the technical program started at 8 o'clock.

The first paper on Friday evening was given by Prof. C. E. Libby of North Carolina State College. The paper comprised a comprehensive coverage of the process for making chemigroundwood as developed under Prof. Libby while he was at Syracuse University. The presentation, including many slides, was interesting, and valuable information was given on new developments on groundwood.

The second paper was given by K. G. Taylor of the J. E. Sirrine Co. who discussed "Job Organization and Construction Coordination." Mr. Taylor covered the topic exceedingly well and the information presented was valuable to those who have expansion programs under way.

The third technical paper was presented by Malcolm B. Pineo of the Brunswick Pulp and Paper Co. and who is also Vice-President of the Southeastern Section. The title of the paper was "The Effect of Sulphidity on Bleached Sulphate Pulp Strength," and the work was done on a mill scale. An excellent discussion and commentary followed the delivery of the paper.

F. B. Doherty, Resident Manager of Rayonier, then outlined the plan for the tour of the mill and gave information that would enable it to be enjoyed to the maximum benefit.

Job Organization and Construction Coordination

K. G. Taylor

THIS paper will be an attempt to cover job organization from the point of the types of contracts and the various setups which may be extended in the constructuion of pulp and paper mills both in the field of expansion and on construction of new mills.

Construction in the pulp industry during the last 20 years has attained a prominent position, and this type of work is a valued account with almost any contractor large enough to handle construction on a scale required by the industry. Over 60 paper, board, and pulp mills have been constructed and are in operation in the southern section of the United States. This does not take into account the number of jobs requiring expansion of existing mills. The construction value of this work has increased year by year, and has resulted in a total investment in the pulp and paper industry to date in excess of 1 billion, 100 million dollars in the South alone. However, it must be considered that the comparative cost of building a mill in the last 15 years has risen at an astounding rate. To clarify this, a mill of say 200 tons daily capacity which in 1937 would have cost approximately 6 million dollars would cost in 1952 over 15 million dollars.

K. G. TAYLOR, J. E. Sirrine Co., Greenville, S. C.

JOB ORGANIZATION

As the topic of this paper indicates, we are covering two phases of building or expanding a mill; the first being job organization. A certain sequence is usually followed when considering the construction of a pulp and paper mill prior to actually organizing the job. Three interested parties are involved in this preliminary work:

1. The owner, who specifies the type of mill he wishes to build and so engages design engineers to prepare details, preliminary layouts whereby the maximum plant efficiency may be obtained; and then meanwhile, an approximate estimate of the job cost is compiled.

2. The engineers, who are engaged for this work, and who must take into consideration the process which will be required in the mill that the owner is planning and the equipment requirements for the type of pulp or paper which is to be produced. The engineers then must prepare the estimate, and upon acceptance by the owner proceed with the design. At this particular point in the preliminary organization of a proposed mill, the engineers accept the responsibility and take the position whereby the owner's interest must be protected, meanwhile supplying the necessary drawings, equipment specifications, and purchasing service to obtain the equipment desired for the installation.

In addition, after the job has been organized and work proceeding, it is the responsibility of the engineers to maintain inspection on the job to assure the owner of value received for expenditures and to see that proper construction practice is followed in accordance with specifications and plans.

3. By the time the contractor appears on the scene, the owner's requirements and job estimates are fairly well established and the time has approached when the responsibility of actually constructing the mill can be passed to the contractor who must balance speed against job economy in order to place the mill in operation within a reasonable length of time.

CONTRACTS

We believe it would be worth while at this time to cover the types of contracts most generally used in the construction of paper mills, since to a certain extent the type of contract or contracts let on the job dictate the actual job organization

G. C. Kimble, Union Bag & Paper Corp.; F. B. Doherty, Rayonier, Inc.; K. M. Guest, National Container Corp.; George Scofield, Rayonier, Inc.; R. H. Stevens, National Container Corp.; and W. F. Brown, University of Florida

both on the part of the engineers and on the part of the contractors involved.

There are three types of contracts which I will take time to cover in detail, but first will cover in a few words in order that you may more closely follow the sequence of job organization under each.

First is the cost-plus-fixed-fee contract which has been used very widely in the construction of industrial plants, especially pulp and paper mills, for which the contractor agrees to carry on and construct a mill for the actual cost, within a certain scope, plus a fixed fee which is settled upon prior to the job being awarded.

Second is the unit price contract whereby the whole project is broken down into component units and items set up on a square foot, linear foot, cubic yard, or ton basis depending upon the type of work being accomplished and the units involved.

Third is the lump sum contract which is coming back into its own with the increasing competition in the construction industry. It was the type of contract, however, which almost went out of existence during and immediately following the last war.

The cost-plus-fixed-fee contract is usually approached with some concern by the owner due to the fact that there is no guarantee as to the final cost of the job other than an estimate to which exceptions can always be taken very easily. Usually, an owner proceeds with some caution in engaging the contractor for this type of work and examines the bidders quite closely prior to awarding a contract. Invitations are usually extended to such contractors as are considered competent for the type of work involved which, in this case, is the construction of a pulp and paper mill. Each contractor is asked to submit an estimate with regard to the scope of work and type of work involved, with the approximate cost and time required for construction, in addition to labor force needed on the job and whatever other considerations the contractor wishes to present.

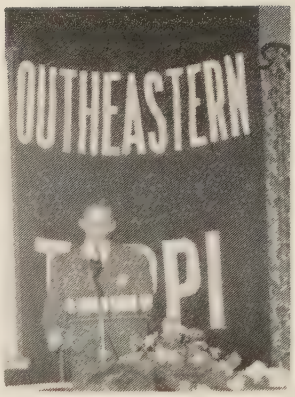
On a job of considerable scope, fee considerations can vary anywhere from 1 to 10%, and are not always the prime consideration in awarding the contract.

It is necessary if the job is to be set up on a fixed-fee-contract basis to also have the contractor submit a table of organization covering job supervision or control, as overhead cost can be just as much a factor in exceeding the total job cost as either labor or material costs. Cost estimates and experience records of various contractors are usually examined rather closely and with all the foregoing taken into consideration, a selection is made by the owner.

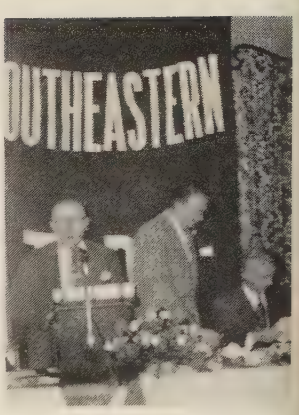
Usually, the job organized on the basis of a fixed-fee contract requires an owner's force of management supervision and an accounting section to handle the owner's purchases, reports, and invoicing. Likewise, the engineers' organization usually consists of an engineering inspection force to handle each phase of the job such as an engineer and several inspectors to cover building work with all its component parts—structural steel erection, reinforcing placing, concrete inspection, and brick work. Individual engineers with the necessary assistants are also required to cover phases of the job such as piping or electrical work, or mechanical work such as equipment installation.

The contractor's organization on a fixed-fee basis of work consists of a cost department, an accounting and payroll department, purchasing and engineering departments, in addition to the necessary superintendents for supervision of various phases of field work.

Organization of a job under a fixed-fee contract is probably not as desirable and does not have the control that can be maintained on construction work by the use of unit price or lump sum contracts. However, the fixed-fee type of contract is necessary on jobs of a particularly large nature due to reasons such as the time element to design a mill of large



K. G. Taylor, J. E. Sirrine Co.



C. E. Libby, North Carolina State College

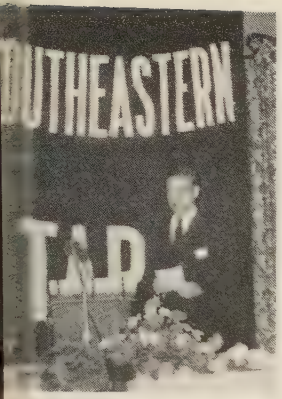
scope, the fact that quite often an owner will award a contract with some phases of a mill still not stabilized which will effect a change to some degree in the scope or type of work the contractor is to perform. These factors applied to unit price or lump sum work would cause an excessive cost burden whereby a contractor would be financing a project running into an investment of many million dollars.

Second, we might consider the unit price contract which, although it has its limitations, is very good for subcontracts under a fixed-fee general contract, or which may be used to break down the work of a job into its individual categories such as piping, electrical equipment installations, etc., but a contract which would hardly be advisable to use as a basis for setting up a complete job. A unit price contract does hold the contractor to fixed charges and allows a limited change in the scope of work whereby the owner is not penalized. However, in order to enter into a contract of this type, a well-formulated description of the job is necessary in order to cover all units involved in the unit price contract.

The third type of contract, which probably from the owner's or engineers' standpoint—and quite often from the contractor's standpoint—is the most desirable, is the lump sum contract. This type alone may not be practical for awarding a contract for the complete construction or expansion of a paper mill; however, the job can be broken down into a sufficient number of categories whereby lump sum contracts can be let. It is necessary on awarding a lump sum contract to have the job well advanced and pretty well stabilized both from the standpoint of the owner and the engineers. There should also be some assurance to a contractor accepting the lump sum job that the scope of work will not increase or decrease within the limits of say approximately 10% either way, since a variance exceeding this percentage may affect the contractor's requirements of construction and his margin of profit and overhead wherein the job may have been figured very closely on a competitive basis.

The lump sum type of contract is a desirable type to award subcontractors under a general contract; or if the job is parcelled to various contractors without the consideration of a general contract, a much more economical installation can be obtained. In such a case as the latter, it is the responsibility of the engineers to coordinate the job directly between the various contractors rather than under the general contractor, which is the case wherein a job is set up under a fixed-fee contract.

Probably the most economical construction organization program which has been obtained to date on jobs of relatively small to medium scope is a combination of the lump sum and unit price contracts set up by phases of work or areas; such as including the wood preparation, power plant area, recovery, digester, and washer room under one building contract, and the remaining portion of the mill under a second building contract. This enables the job to proceed within a reasonable



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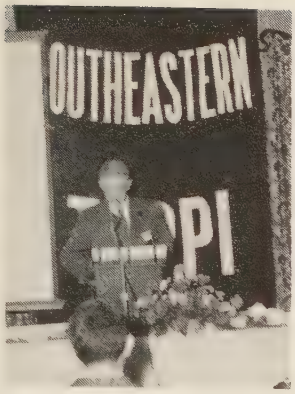


F. B. Doherty, Rayonier, Inc.

gth of time without having complete and final plans on the ore mill, which you know takes months and months to de-op. Also, as the various portions of design are completed, ely electrical and piping design, contracts can be let in-pendently of other work such as buildings which can already in the process of construction.

Some of the work that can be let on the lump sum basis is of se the building work, the necessary underground work, mbing, heating, and ventilating. The electrical work can awarded on either a unit price or lump sum basis; and the ping and equipment installation can usually be awarded on nit price basis. Quite often it is preferable from both the ndpoint of job organization and coordination to have the jor vendors erect their own equipment. This can be ac-mplished usually in the way of boiler erection, heating and ntilating, tanks, precipitators, or tile chest work. By this ans, quite often a better installation is obtained as a result the manufacturer's desire to give the owner an installation ich may mean repeat orders or industry-wide acceptance of brand of equipment.

Before leaving the job organization, I would just like to re-w briefly the skeleton requirements for maintaining a com-ent and yet efficient organization on any job. Of course it necessary to adjust the organization of any project accord-to the size of the job and, in some cases, the departments supervisory personnel listed may be either reduced or elim-ted altogether.

First, the owner of course usually keeps on the job a mill nager and possibly an assistant; also a plant engineer or ster mechanic. In addition to this, it is necessary for the ner to maintain his own purchasing force, accounting depart-nt, and later as the mill nears completion to place the va-us departmental operators out on the job to familiarize mselves with equipment and process.

The engineers maintain a resident engineer with necessary istants and inspection personnel to audit the contractor's ounts and payrolls; assist the contractors with identifying ipment and warehousing; to inspect construction and ipment, electrical and piping installations; survey crews make initial layouts; and such engineers that are neces-y to check shop prints, make changes on drawings and keep contractor up-to-date with the latest design information.

The contractor's organization is usually headed up with a ject manager, the necessary field superintendents and eral foremen, a purchasing force to obtain construction erials, an accounting department to process invoices and rolls, an engineering department to keep job costs and edules, field engineers to lay out contractor's work, ware-sing personnel to handle and store equipment, the neces-labor for satisfactory progress of the job, and competent contractors to carry on portions of the work which may be idled in a more economical manner by parceling out special k.

It goes without saying that the majority of the above-mentioned force on the part of the contractor is usually set up on a fixed fee job. Nevertheless, it amazes one no end to see how few of the above overhead are actually needed on individual lump sum or unit cost contracts whereby a contractor quite often operates with only a superintendent, a warehouseman, and a combination time checker and paymaster.

CONSTRUCTION COORDINATION

Now to the second portion of our topic—construction coordination.

The prerequisites of proper job coordination are efficiency of inspection, cooperation among the various contractors and subcontractors, and organization of the contractor's supervisory force whether of a general contract nature or individual contracts whereby proper information is passed down to the man making the actual installation.

Coordination of the job itself does not reach the degree of importance in the earlier stages of construction as in the latter part of the job when work approaches completion and start-up schedules are anticipated. It is of utmost importance, however, that in the whole job from the time the grading is started until the last piece of machinery is in operation to assign engineers and competent contractor's supervisors to handle the particular phases of work. We have already covered this to some extent, however, the success of any installation by a crew of pipe fitters, electricians, or millwrights, whatever their trade may be, depends on the coordination of work between their immediate supervisors and engineers assigned to that portion of the job.

Also, as in the case of separate contractors not being responsible to a general contractor, it is of prime importance to schedule the work of contractors in each work area so that conflicts may be kept to a minimum and the job economically handled.

In the first phases of the job, a meeting with the general contractor possibly once a week to coordinate work and to discuss subcontracts or owner's requirements is necessary in order for the three parties involved—namely the owner, the engineers, and contractor—to have a mutual understanding as to work progress. Where the job is set up with individual units and lump sum contracts, it is necessary to bring the top man on the job in each of the contractors' organizations together at least once a week in order to obtain proper scheduling of work.

In the latter phases of the job when there is a good chance of several contractors working in one area finishing up an item such as the paper machine, semiweekly or even daily meetings are necessary to keep maximum coordination among contractors and crafts.

There is always a tendency toward the latter phases of the job to rush its completion through the use of overtime work. Whether this is economically feasible and at what point is something that should be examined closely in order to anticipate problems which will certainly arise in the offering of premium time work to one or several trades on the job.

There are several reasons why the contractor or the owner may deem it advisable to enter into premium time agreements or step up the progress of the job in order to meet a preconceived completion date. This desire to increase construction tempo may be attributed to a delay in delivery on such items as structural steel or major pieces of equipment. Also, one contractor or one phase of work may be lagging behind the remaining portions of the job due to congestion in certain areas causing the contractor to fall behind in his work, or even preventing him from starting work on an anticipated schedule.

The expenditures of a stepped-up program requiring premium time must be weighed against the commitments from contracts for pulp or paper entered into by the owner with various customers, and by the owner's estimate of the cost of lost production in extending the job past the anticipated completion date. However, it should be stressed that it is most

uneconomical to place any job on an overtime basis before thoroughly examining the anticipated time of completion as against projected dates of operation of various areas, and to know that these dates are within reach of the contractor and can be safely assured by him.

Even before a job starts, man-power requirements should be pretty well worked out by the contractor, with a gradual build-up in a period of time anticipated whereby the maximum number of men can be utilized with the greatest economy to attain the necessary speed to bring the job to its predetermined completion date. If this man-power requirement is pretty closely adhered to and is based upon sound construction practice and experience records of the contractor, premium time whereby the owner is uselessly penalized will be kept to a minimum.

Before completing this paper, we should spend a few minutes on the real job of construction coordination which comes at the very end of the building program when the day of start-up approaches.

Start-up of a mill can more easily be handled by department, and the scheduling of contractors should be set up whereby, as the trades move out of a mill department, inspection personnel and start-up personnel may move in to check out equipment and test the various systems. This all takes time and it is desirable to stagger the start-up operations in the various departments in order that an area may be thoroughly checked out prior to turning over to the owner for operation. Should more than one area be tested out or made ready for start-up at one time, the most efficient plan is to assign area engineers working independently with inspection crews and start-up crews in order that the mill may be placed in operation in the desired sequence.

Since there is a deadline usually to meet on start-up, this part of the job is most pressing and requires more coordination than at any other time during the course of construction. Also, the time has come when the owner must place his own operating personnel in the areas of start-up to work with the contractor's men and the engineers, and be ready to take the operating departments over. As mentioned before, this is more easily attained by the assignment of one man designated as an area engineer to coordinate these three interested parties so that the mill may be placed in operation with the least effort and the minimum loss of time.

CONCLUSION

In conclusion, it may be safely ventured that the pulp and paper industry, especially in the southern portion of the United States, has taken its place in the construction field as one of the most outstanding clients for the engineer and contractor.

From all indications, although in the next decade there may be fewer new mills constructed, it is the writer's firm belief that with the combination of new mills and expansion programs of existing mills that the paper industry will continue to be a coveted client among the contracting organizations.

We are witnessing in our time the establishment of the paper industry in the South to which the Nation may look in the future—and is even looking to now—for a varied and complete market of paper products. We are fortunate in being in on the ground floor of this revolutionary development.

Lake Erie

The November 21 meeting of the Lake Erie Section was held at the Hotel Carter. The subject for the evening was on packaging films. The title of the talk was "The Battle of the Films." The speaker was J. M. Cowan, Managing Director, National Flexible Packaging Assoc., Cleveland, Ohio. Mr. Cowan brought out briefly the history, availability, and unique properties of each of the types of commercially available transparent films.

L. E. Rolig, *Secretary*

The Battle of the Films

John M. Cowan

I should like to clarify one point in the announcement of the message I am supposed to deliver tonight—a message of interest to production and technical men. I don't want to appear as a sheep in wolf's clothing or as a wolf in sheep's clothing. I suppose the suit I'm wearing is wool though it's hard to say these days. You certainly have a perfect right to ask, "what has an ex-advertising man, an ex-salesman, and promotion and marketing man got for me?" It's a good question.

My only technical qualification is an engineering degree way back when. I do, however, have a great liking and respect for the technical men in our business community. They are the most objective and level headed element in our society. Their language, the language of science, is based on plain, simple truth and after countless harangues, and "you're another" on radio and television during recent months, it's a relief to get down to straightforward and direct exposition again. My only gripe, and I'll pass over it quickly and lightly, is the technical man's general fear and distrust of emotion. He is not himself immune to emotional factors, but he too often assumes that major business and major personal decisions are based on reason and logic. Gentlemen, it ain't necessarily so.

Apropos of that, a self-confessed intellectual, writing to *Time* magazine seemed puzzled and hurt at the inference that the common people were more intelligent than the intellectuals. An old definition should set him right. It goes like this, "A highbrow (substitute egg head) is a person educated beyond his intelligence."

This great film industry, which I will discuss, has emerged, we won't say grown up, it has emerged within a single generation. It would never have come so far and so fast if it were not for subconscious emotional factors. Men, women, and children are attracted by the sparkle and glitter of transparent films. In viewing foods and candy in transparent packages, whether glass or film or plastic, the sight of the product actually makes them hungry and serves as a reminder of a want. No type matter, not even a beautiful picture on an opaque surface can create such a sharp emotional response.

Even the feel of most films is pleasing to the touch.

In transparent film, the product is nude—but protected. However, it would be equally mistaken to assume that transparent films were only merchandising gadgets. These possess as well, unique functional characteristics.

My own personal recollection of cellophane goes back to 1924. I was just a young fellow doing the rather prosaic duties always associated with the bottom of the business ladder. One day, I read in a Sunday supplement an enthusiastic story about a glass-clear, flexible material called cellophane which Du Pont was going to manufacture in Buffalo, N. Y. It caught my imagination. I thought, "Wouldn't it be fun to work on a product as new and promising and exciting as that must be?" Seven years later, through sheer luck, I was on the Du Pont payroll in the cellophane division.

Cellophane was developed in France, and its first use of consequence was for the windows of gas masks used by the French army in World War I. Du Pont started up in 1924. The early film was nonmoistureproof, very brittle by today's standards, and sold for $2.65 per lb. Most early customers kept the precious stuff in the safe, literally.

In 1927, a moistureproof coating was developed which enormously expanded the markets for cellophane by giving it moisture-vaporproof properties. A few years later, the Sylvania Co., of Fredericksburg, Va., developed a heat-sealing type of coated film which simplified wrapping operations and

John M. Cowan, Managing Director, National Flexible Packaging Assoc., Cleveland, Ohio.

adapted cellophane to much existing equipment and avoided the installation of glue pots on wrapping machines.

The first printing on cellophane occurred in 1926. The first machine-made containers appeared in 1928. They were little tubes for cigar packaging. Cellophane bags in larger sizes quickly followed. Today, the cellophane manufacturers turn out about 300,000,000 lb. of film a year, of which about 40% is converted. The latest entrant into the field is Olin Industries who started up last year.

Today, there are about 57 varieties of cellophane if you write in the three gages in which it is offered. These differences in formulation and performance were developed to suit particular end uses. Because of these variations, one cannot generalize too broadly on the properties of cellophane. There can be no doubt that it has earned its way as a general purpose packaging film of very wide utility. Du Pont's technical section has compiled an $8^1/_2$-column, single-spaced list of end uses and film recommendations. However, the cellophane manufacturers would be the first to admit that their film isn't a universal answer. There are many technical requirements for which it isn't suited. One of these springs from its shrinkage characteristics. This makes it difficult to laminate to board or paper since the shrinkage induces curling. Chemically, cellophane is related to viscose rayon. It is odorless, greaseproof, relatively impervious to gases. It can be made moisture-vaporproof in varying degrees. It is not considered waterproof. The quality controls which have been developed by the various manufacturers insure a notably uniform product with gage and yield variations not exceeding 5%.

Another film which has found wide packaging applications is Pliofilm, a rubber hydrochloride sheeting made by the Goodyear Tire and Rubber Co. As a laboratory baby, it first appeared in 1923. No commercial production occurred until 1932. Its early use was in the fabric replacement field for rainwear, umbrellas, garment bags, card table covers, etc.

In 1936, it got its introduction as a food packaging medium. Pliofilm has good dimensional stability. It may be sealed by the use of heat alone or by using heat and adhesives. The seal formed is a weld and not merely a surface adhesion. It can be printed by all commercial methods and formed into bags.

Pliofilm has the unique property of stretching under application of heat and can be stretch wrapped.

Primary markets include fresh meat pre-packaging, a field pioneered by a one-side coated cellophane. Both products share this market today. Meat loaf casings and stretch wrapping of chunk bolognas and luncheon meats and cheese packaging are other applications. Both heavy and light textiles, including sheets and pillow cases and bolts of cloth are being Pliofilm wrapped though other films or film laminations are in this same field.

An increasingly important use is for the manufacture of coffee bags in combination with kraft paper. It forms the inner ply of the bag. Here its property of permitting escape of (CO_2) gas but of barring oxygen entrance is of importance. In the field of fresh fruit and vegetable packaging, it has been further widely used for the heavier unit weights, say the range from 3 to 10 lb. Automatic wrapping of lemons and lettuce with very light gage material has been perfected. Laminated to other films or foils it plays a part in liquid-tight pickle and sauerkraut packages or frankfurters packed in sauces, and in gas packing of such products as yeast and dried milk. A variety of formulations have been developed to suit different final use requirements. One of the most radical is the type used on oleomargarine, the so-called "squeeze bag" which permitted the housewife to distribute the coloring matter through the product by kneading the package.

Today, most types of wrapping machines can be adapted to handle Pliofilm. Another laboratory baby which leaped into commercial production almost overnight is Saran, a product of the Dow Chemical Co. In the early 1940's, the Frigidaire Div. of General Motors were large producers of machine guns. They were looking for an improved protective package. In some manner, they got hold of a sample of Saran, polyvinylidene chloride, an experimental sheet, and put it through evaluation tests without Dow's knowledge. Its moisture-vaporproofness far exceeded any other known film. Frigidaire got excited and demanded that Dow go all out to produce it. The original type M smelled to high heaven. It could not be heat sealed so it was produced in the form of tubes and after inserting a machine gun or other part, the ends were closed by the use of lead rings. Since then, new types have been developed which are odorless, fully transparent, nontoxic, and heat sealable by special techniques. Type 517 came out in 1946. It is highly moistureproof, chemically resistant, and with good strength and aging properties. Major uses are in the meat, cheese, dried fruit, and baked goods industries. Processed meats such as liver sausage, chili, salami, and meat sauces are packed in fabricated casings. It also has found application on luncheon meats both as an overwrap and as a vacuum package.

Dried fruits packed in Saran bags include apricots, prunes, apples, pears, and peaches. A starch dusted type of film is used to insure easy opening of the bags.

Saran wraps of cheese function both as consumer packages and as controlled, protective containers for aging 40 to 60-lb. curing blocks. Pliofilm and wax-coated cellophane also operate in some of these applications. Among baked goods, graham crackers, saltine crackers, and fig bars are leading product uses where extra protection against moisture gain or loss is desired. Other films still predominate in this area. Saran also has electrical insulation uses.

A modified type of Saran is called "Cry-O-Rap." It is produced by the Dewy and Almy Chemical Co. by extrusion of chemical formulations supplied by Dow. It is widely used for poultry packaging. The fowl is inserted into a bag, the air withdrawn, and a quick dip in hot water causes the film to shrink and cling to the bird like a second skin.

One of the youngest and most phenomenal film formulations is polyethylene. The basic development must be credited to the British. The flake production rights were assigned to Carbide and Carbon and Du Pont. I think it might be defined as a high atomic weight paraffin compound. Unlike any other commercial film of which I have any knowledge, polyethylene is a pure chemical with no softeners, other additives, or coatings. It is produced in film form by extrusion through the use of heat and pressure alone. Polyethylene has unrivaled low-temperature characteristics. Like other homogeneous films, Pliofilm for one, the moisture-vaporproofness of the sheet inproves markedly as temperatures are lowered. It is highly shock-resistant but has a nonreturnable stretch when subjected to too much strain. It retains its flexibility to $-60°$ F. It is heat-sealable but with a narrow sealing range. It is highly insoluble which has made adhesive gluing and printing extremely tough technical problems. Different printing techniques have been evolved which now provide a fairly satisfactory answer. Machinery for wrapping purposes is under development.

The first extrusion of polyethylene film in America occurred just eight years ago, in 1944 at the plant of the Visking Corp. Currently, there are ten or more in this business and others applying it as a coating on film, paper, foil, or board. Its first use, in an olive drab color, was to package machine guns, rifles, and other small arms. Since the war, a remarkable number of civilian fields have been exploited while its military packaging use is still important. The price has declined 50% since 1946. Important outlets are as case and drum liners, and as packaging for fresh produce, textiles, frozen foods, candy, soap, hardware, silverware, and a dozen other

growing uses. Total tonnage for packaging uses as unsupported film is probably well over 30,000,000 lb. per year and the curve is still up. Don't be misled though by the total figures you may read on polyethylene flake production. Packaging uses must battle for their share against squeeze bottles, ice trays, electrical cable and wire insulation, molded products, water pipe, and a host of other interesting applications. The future of polyethylene is assured both in pioneering new uses and in taking over some for which other films are less well adopted or higher in price. Well-informed persons predict its packaging uses will be tripled or quadrupled within the next five years. Vinyl films in the lighter packaging weights have not made too much progress in unsupported form. A rather low moistureproofness and a rather high price have limited its growth. The major use has been as a laminated heat-sealing and greaseproof element in military barriers though coated polyethylene constructions now available are offering stern competition.

Cellulose acetate film was first made by the Celanese Corp. in 1934 as safety film for motion pictures. It was first offered in packaging in 1937. They are still the major supplier. Eastman then came in followed by Du Pont. Celanese have reported a 300% expansion in capacity since 1949 with further expansion planned. It is manufactured by both casting and extrusion methods. Acetate film is dimensionally stable, has a fine printing surface, and is widely used for laminating purposes on paper and foil. It it greaseproof, waterproof, but highly permeable to water vapor and CO_2 gas. This has won it wide publicity as the "breathing wrap" and guided its adoption for tomato tray overwraps, for spinach bags, and other produce uses. Other films achieve this characteristic by perforation. It has good aging characteristics. It is often used for the windows of window boxes, window bags, and envelopes and to give a lustrous, greaseproof, soilproof surface to printed matter and boxes. Here, new coating techniques are competitive. It has found considerable use for wrapping of stationery and light textiles where its nonshrinking characteristics are advantageous. A considerable amount is used in the electrical industry both as tape for wire wrapping and laminated to paper as slot cell insulation. Total tonnage capacity for packaging purposes is in the neighborhood of 13,000,000 per year. It is another of the important packaging films. Eastman Kodak make a cellulose acetate butyrate film which has many of the properties of cellulose acetate plus additional toughness and shock resistance. That has brought about parallel uses to cellulose acetate where the additional factor of safety has justified a somewhat higher price. The final film is Du Pont's newest chemical creation. It is known as "Mylar" polyester film. It excels all other films in strength and shock resistance. The film is stable up to 302°F. and its high dielectric properties especially recommend it for electrical insulation. It also behaves well in the lower temperature range which should recommend it for plastic glazing for storm windows. It would appear ideal for textile packaging and many other uses where its amazing shock resistance would be helpful. Unfortunately, the present production is extremely limited and Du Pont appears to have no plans for immediate expansion. "Mylar," though, is a name to remember. We can predict in time it will take its place in this growing family of transparent film materials.

Continuing this theme of the future, what can we expect in the way of future growth for all types of flexible packaging? Several factors should be mentioned:

1. The growth of unit packaging. The idea received great impetus during the War with the enormous production of concentrated rations in unit packages. It offers both convenience and utility. It is an ideal sampling medium. It offers great marketing possibilities. We can predict a great growth of one-shot or single service marketing. This will require more packaging material, especially of laminated types since protective requirements are in almost reverse ratio to the package size.

2. A growing sanitation consciousness. Some of us can remember when bread was unpackaged. Today it is a rarety. From school children on up, we are getting more germ conscious. We want our food protected. Fresh fruits and vegetables represent a huge field for packaging expansion with no more than a 10% penetration to date. Every film we have mentioned can be used somewhere to accommodate the varying technical needs of this market.

3. Higher living standards and intense competition at manufacturing and retail levels both encourage increasing efforts to improve packaging. Merely delivering a product physically intact to Mrs. Housewife is no longer the limited objective. The growth of prepared mixes and complete meal services again increase packaging requirements.

4. Fractional packaging such as that involved in wrapping each quarter pound of saltines in a 1-lb. container doubles or triples the packaging needs of the product. It is another favorable trend.

5. The growth of self-service or self-selection. Super markets today are not merely food purveyors. They sell textiles, drugs, and many other nonfood items. They have proved their ability to move merchandise at lower cost than any other marketing medium. Other outlets, drug stores, hardware stores, ten cent stores, and department stores are already exploring similar techniques. This trend will pick up speed very rapidly. It requires more packaging than the methods now in use.

6. Finally, our population growth is another promising factor. Every day, 7000 new babies appear on the scene, 7000 that is, in excess of deaths during the same period. That's about $2^1/_2$ million per year, equivalent to two new cities like the Cleveland area with all its marketing demands every 12 months.

All of these favorable factors combined should permit reasonable optimism for the fully qualified packaging supplier at any level. The transparent film industry will get its share of this new business. So will glassine, waxed paper, aluminum foil, boxes, shipping cases, and steel drums. Despite the rise of transparent films in the last generation, other flexible materials have shown similar growth and expansion. We expect this to continue.

If you look at the chart, it is apparent that the birth rate on new film types is stepping up. If this is continued, the next ten years may well see the birth of quite a number of new materials. They may be refinements or improvements in existing types or chemically new developments. One such possibility is a nylon film. It has already appeared experimentally as a coating. Whether it has enough advantages to offer volume possibilities at a price the market will accept are matters wholly beyond my knowledge and information. To guess what other films may be hiding in research laboratories across the land would be pure speculation. We should perhaps observe, that not all films make the grade. Quite a few have appeared briefly, disguised under code numbers, without publicity and as quietly have disappeared because they failed to meet the exacting requirements of raw material availability, utility, or profitability for their sponsors. There may well be many more such still-born babies in the future.

By now, you must agree that no film can be sure of unlimited exploitation of a particular market undisturbed and without competition. Not only is there intense competition within the film family, but improved engraving and printing techniques for papers and boards which give amazing realism, reduce somewhat the advantages of product visibility. Coatings on paper and board which convey brilliant surface sheen or add greaseproof properties and moistureproof-vaporproofness compete with film laminations. Window boxes offer partial product visibility with generally more

rugged strength and stacking ease. Glass jars and rigid plastics are still in business. Tin cans are moving into the frozen food field formerly owned by box overwraps of film or paper by means of beautiful lithographing on the metal or a paper band. Concentrated frozen orange juices showed the way. Now berries in juice are following. But a counter-attack is under way. Laminated films are used for unit service orange juice packages so the battle is by no means over. The vast ingenuity, the free competition, the unexcelled markets we possess, all insure that new and better packaging will appear tomorrow for the benefit of supplier, manufacturer, and consumer alike. *Fortune* magazine recently defined "industrial selling" as the highest type of salesmanship in America. I would not quarrel with that definition. I think it is valid and well justified. For me, it helps define packaging as the most fascinating business in the world.

Q. Is there a standard test for the permeability of films to carbon dioxide?

A. Yes, such as is used to test coffee bags.

Q. Can Mylar be laminated?

A. Yes—it is being tested as a component in military barrier materials.

Q. Have any of the films dimensional stability?

A. Polyethylene has dimensional stability. So has Mylar, although supply wise, Mylar is only a dream. Other films have it to varying degree. Unsupported cellulose acetate, while dimensionally stable, tends to take a set when creased or folded and shatters at that point under certain circumstances.

Q. Does the per cent of moisture present in a film affect the rate of development and/or retention of the electrostatic charge?

A. It may be a factor—affected to much greater extent by the humidity of the surrounding atmosphere—high humidities tending to "bleed" the static from the film.

Q. Are film thicknesses uniformly constant and are they covered by standard specifications?

A. In the case of polyethylene, it seems difficult to maintain gage within less than a 10% tolerance without established standards. This gives unfair advantage to unscrupulous producers and/or converters as reduction in gage greatly increases surface area of a given weight of film. This is frequently not traceable as most films are unidentifiable. Du Pont tried to sort of "watermark" cellophane with a "D." This practice was discontinued because of purchaser opposition. In the near future, a meeting will be called under the joint sponsorship of the Society for the Plastics Industry and the National Flexible Packaging Association, to set up voluntary industry standards on polyethylene film.

Q. Retail store advertisements generally refer to film wrapped articles containing articles as "plastic." Is this desirable?

A. For a long time "plastic" was a magic word. Then poor performance made it a detriment rather than a help. Currently, educational programs, backed by the Society of the Plastics Industry and by many individual manufacturers, are under way.

Q. Can films be colored in the original processing operation? And, if so, which films?

A. Acetate, Pliofilm, polyethylene, and cellophane are available in colors. A dye or pigment is generally used for this purpose. Color films are specialties—not necessarily stocked items usually only run on order. It therefore is frequently more convenient for the converter to do his own coloring—usually by means of a printing operation.

Q. Is the per cent of moisture present in film important? Critical?

A. Moisture present is particularly important to cellophane; too dry it becomes brittle—then shatters or fractures easily. Most printing—and many laminating processes dry the film—some unduly. If uncontrolled this can readily become critical.

Q. Some cellophanes are referred to as "waterproof." Is the nomenclature correct?

A. No, it is not correct. MST, for example, is definitely not waterproof. Two coatings must be used to approach this standard. The "Anchor" type improves coating adhesion but would not be termed "waterproof."

Q. Is any use being made of polyvinyl alcohol film?

A. PVA has the unique property of being water soluble. It could, for example, be quite embarrassing if the film would disappear from a package when caught in the rain. The Du Pont Co. who formerly made this product has withdrawn from the market and is referring inquiries to Reynolds Metals who are marketing a PVA film.

Q. Will the price of films become low enough for the films to compete with old-line standard packaging materials such as glass or tin?

A. The cost of a number of films is less than the actual cost of tin—but the tinplate has a vested interest in the existing packaging equipment previously installed for its use. Newly developed and still to be developed packaging equipment can alter this relationship. The use of the flexible orange-juice package is an example. It is much less expensive to use than tin. Further development of the "individual portion" package is another important factor. This field has good possibilities.

Q. How does Teflon compare with Mylar?

A. Teflon is available, although not in great volume. It has terrific heat resistance and reduces adhesion—is extremely "slippery." It is being sprayed and/or baked onto many adhesive machine parts and heat sealing bars to reduce "build-up" of adhesive or coating. It also has very fine dielectric properties. It has not yet been made cheaply.

Pacific

In March of 1952 the Pacific Section of TAPPI invited Karl Freudenberg of Heidelberg, Germany, to come to the United States and present the lectures of the Sixth Annual Seminar to be held in the Fall of 1952 in Portland, Ore., and Seattle, Wash. This invitation was tendered after having been agreed upon by the Executive Committee of the Pacific Section of TAPPI and after advice that some financial support for Dr. Freudenberg's trip was available from National TAPPI, an acceptance from Dr. Freudenberg was received a few weeks later.

Dr. Freudenberg is a very distinguished chemist whose biography has recently been described by R. E. Oesper in the *Journal of Chemical Education*, pages 4 to 6, 1951. Dr. Freudenberg has been and now is professor and director of the Chemisches Institut of the University of Heidelberg. He is also director of the Research Institute for Chemistry of Wood Polysaccharides at Heidelberg. He was born in Germany in 1886 and received his Doctorate Degree in 1910 at the University of Berlin, where he worked under Dr. Emil Fischer. He spent from 1914 to 1918 in the German army. During the time from receipt of his Doctorate Degree to the headship at Heidelberg, he held university posts at Kiel, Munich, Freiberg, and Karlruhe. He carried out many researches in the field of organic chemistry and natural products. He has written four books and more than three hundred scientific papers and is without doubt one of the world leaders in the field of cellulose, lignin, and wood chemistry. A pleasant letter has been received from Dr. Freudenberg expressing his thanks to TAPPI and to those who helped arrange his trip.

During the several months after receiving Dr. Freudenberg's acceptance, an itinerary was developed. The arrangements with the various TAPPI local sections were worked out by W. F. Hathaway, chairman, TAPPI Local Sections Committee, with Pacific Section TAPPI and Western Section of CPPA by Joseph L. McCarthy, University of Washington, and with California groups by Robert G. Swain, of Stanford University. In general, an honorarium was paid to Dr. Freudenberg for his addresses to groups other than TAPPI groups. For the TAPPI groups, National TAPPI covered travel expenses of Dr. Freudenberg from Heidelberg to Seattle and return plus other side trips to local section meetings, less the seminar income, and with the local sections taking care of local hotel expenses.

More specifically, the final schedule followed by Dr. Freudenberg was approximately as follows: (a) Sunday, September 7—arrived in New York, (b) Wednesday, September 10—addressed Lake States TAPPI Section in Appleton, Wis., on "Lignin and Its Formation in Plant Tissue," (c) Thursday and Friday, September 11 and 12—lecture at The Institute of Paper Chemistry, (d) Saturday, September 13—visited at the Tanners Council Laboratory (Dr. Fred O'Flaharty) in Cincinnati, Ohio, (e) Monday, September 15—addressed Ohio TAPPI section in Middletown, Ohio, on "Lignin and Its Formation in Plant Tissue" with small group meeting in the afternoon, (f) Thursday and Friday, September 18 and 19—

delivered Pacific TAPPI lectures in Portland, Ore. on "Recent Research on Cellulose and Lignin," (g) Saturday, September 20—addressed Oregon Section, American Chemical Society, on "Natural Tannins," (h) Monday and Tuesday, September 22 and 23—delivered Pacific TAPPI Seminar Lectures in Seattle on "Recent Research on Cellulose and Lignin," (i) Wednesday, September 24—addressed Puget Sound section, American Chemical Society, on "Natural Tannins," (j) Thursday, September 25—addressed University of Washington graduate chemistry and chemical engineer seminar on "Configurational Relationship Between Sugars and Alpha Substituted Fatty Acids and Hydrocarbons," (k) Saturday, September 27—addressed Tri Association luncheon in Victoria, B. C., Canada, on "Formation of Woody Tissue," (l) Wednesday, October 1—seminar at California Institute of Technology, (m) Thursday, October 2—lectured at Chemistry Department at UCLA, (n) Friday, October 3—addressed evening meeting of the Southern California section of American Chemical Society, (o) Tuesday and Wednesday, October 7 and 8—lectured in chemistry Department at Stanford University, (p) Thursday and Friday, October 9 and 10—lectured at Stanford Research Institute, (q) Monday, October 13—addressed evening meeting of the California Section of ACS, (r) Friday, October 17—lectured in San Diego as arranged by Dr. Heuser, (s) later October—possible lectures in Emory University and Georgia Institute of Technology at Atlanta as arranged by Dr. Werner Bruechmann, (t) approximately November 1—leaving New York for return to Heidelberg. Mrs. Freudenberg accompanied Dr. Freudenberg during most of the trip.

The Sixth Annual Seminar Lectures given by Dr. Freudenberg in Portland and in Seattle were announced by sending out copies of an announcement along with a letter inviting attendance. About 35 persons came to hear the lectures in Portland and about 47 in Seattle of whom some were nonpaying guests from research institutions or universities interested in wood chemistry and pulp research. It is the impression of the writer that Dr. Freudenberg's lectures were well presented and entirely justified the effort and expense associated with his trip and with the assemblage of the several audiences. Dr. Freudenberg has indicated that he has submitted for publication in *Tappi* magazine two papers setting forth a summary of his lectures.

In conclusion, the writer would like to render most sincere thanks to all those who helped arrange Dr. Freudenberg's trip and particularly to Mr. Hathaway and to Dr. Swain. It may also be proper at this place to record thanks from the Pacific Section to National TAPPI for aid rendered which made possible Dr. Freudenberg's trip and his Pacific TAPPI seminar.

Joseph L. McCarthy, *Seminar Committee*
Pacific Section TAPPI

Ohio

On Tuesday, November 18th, the annual Joint Meeting of Ohio TAPPI with the Miami Valley Div. of the American Pulp and Paper Mill Superintendents Association was held at the American Legion Hall in Middletown, Ohio, with a total attendance of 212.

Each alternate year Ohio TAPPI sponsors the combined meeting but this year it was sponsored by the Superintendents Association.

H. B. Thacker, Distribution Engineer in the Electric Utility Department of the Westinghouse Electric Corp., East Pittsburgh, Pa., spoke on "Power Distribution Systems for Paper Mills."

Mr. Thacker emphasized the importance of the proper layout of paper mill electric systems at the time the original distribution system is placed on the drafting board. The initial electric distribution system in a given plant will cost between 2 and 10% of the total building cost depending on how important the mill considers the following factors:

1. *Reliability* with respect to time and duration of outages.
2. *Flexibility* or its ability to handle growing loads economically.
3. *Voltage regulation* or how will the voltage vary from no load to full paper mill load. What is the effect on voltage when starting the largest motors in the mill.
4. *Efficiency* dictates that losses in the system be reduced to a minimum but distribution at 4000 or 13,200 v. for mills with larger loads and using transformer to stepdown voltage near large concentration of 440 or 550-v. motor leads.
5. *Low maintenance cost* means maintenance with a minimum of lost time and a minimum amount of labor to keep system in good working order.
6. *Initial cost* should be considered after the above factors to be certain that all of the above conditions are met in the final layout.

Following Mr. Thacker's presentation a film entitled "Selecting the Right Distribution System" was shown which outlined the eleven types of distribution systems from the simple radial system to the more involved systems including industrial primary and secondary network protectors.

Following the film Mr. Thacker explained the basic elements of system planning. The paper mill should first know the loads and load locations before beginning to make a layout. Electrical manufacturers have spent many years in development to produce more reliable individual pieces of equipment such as totally enclosed motors and better circuit breakers with higher interrupting capacities on 440 and 550-v systems which permit larger capacities and concentrations of load on individual load center distribution equipment.

This equipment all becomes ineffective with one distribution system failure due to improper design and in a paper mill the failure of one piece of equipment or one part of the distribution system shuts down the entire mill if service is interrupted even for a fraction of a minute.

If the paper mill goes down production time loss may be several hours. A conservative estimate of the average loss for such a shutdown is $2000 per hr. and it does not take many such shutdowns to pay for a more reliable distribution system.

This has led electrical manufacturers to develop the use of the industrial network protector with which it is often possible to completely reduce power failures on distribution systems to a very low figure. The primary selective radial system with two primary circuits, each three-position switches, has the highest over-all rating based on the six considerations in selecting distribution systems outlined above.

Even if a paper mill has the latest and best equipment such as totally enclosed motors where water could get into motors, and high interrupting capacity circuit breaker, an inadequate electric distribution system can cripple operations and result in heavy losses to the paper mill operator.

The proper design of the paper mill distribution system is a job requiring considerable experience and initiative and anyone faced with the problem should seek the help of those having such experience.

A. M. Cooper and R. R. Baker of the Westinghouse Corp. were also present for this meeting.

G. B. Gregg, *Recording Secretary*

Lake States

The second Lake States TAPPI meeting of the 1952–53 season was held in Appleton in the afternoon and evening of Nov. 11, 1952, with approximately 200 in attendance.

The Institute of Paper Chemistry graciously acted as host for the afternoon session, and arrangements for the program were made by Donald J. MacLaurin, Head of the Pulping and Paper Testing Groups at the Institute, and a member of the Executive Committee of Lake States TAPPI. The evening session held at the Hotel Conway included a social hour, dinner, and an after-dinner talk, on free enterprise entitled "Sell for America," by W. F. Luckenbach, Jr., Manager

J. A. Van den Akker, R. P. Whitney, W. R. Haselton, W. A. Wink, and D. J. MacLaurin, all of The Institute of Paper Chemistry

Industrial Sales Department, Virginia Smelting Co., Norfolk, Va.

The afternoon activities began at 1:30 p.m. with a tour of the extensive and impressive facilities of the Institute, with Institute staff members serving as guides. Arrangements for the tour were directed by George A. Graham, administrative coordinator of the Institute.

The tour was followed at 3:30 p.m. by the formal program in the lecture room with Mr. MacLaurin leading a panel discussion on "Papermaking Properties of Pulps." The following presentations were made:

1. The Drainage Properties of Pulp Slurries, by Roy P. Whitney, Head of the Chemical Engineering Group.
2. The Equilibrium Moisture Content of Pulps, by Willmer A. Wink of the Physics Group.
3. Comment on the Optical Method for Determination of Bonded Area of Pulp Sheets, by J. A. Van den Akker, Head of the Physics Group.
4. Gas Adsorption as a Technique for Measuring Fiber Surface, by W. R. Haselton, candidate for the degree of Doctor of Philosophy. This was a preliminary report on his thesis work.
5. Some Relationships Between Refining Methods and Sheet Strengths, by Donald J. MacLaurin, Head of the Pulping and Paper Testing Groups. Due to lack of time this paper was presented by title only.

Mr. Whitney discussed the basic principles and concepts of water drainage from pulp slurries with particular respect to freeness tests and filtration effects. He showed how these concepts of drainage rates and specific filtration resistance can be expressed by mathematical formula. In answer to questions at the end of his talk, Mr. Whitney stated that stock temperatures seem to affect only the viscosity of the water, and that fiber length distribution of a pulp affects drainage rate by its influence on the compressibility of the pulp mat formed.

Mr. Wink emphasized the important bearing of equilibrium moisture content of pulps on the many important properties and uses of paper. He described and illustrated the ingeniously simple Wink cell unit for humidifying and weighing samples of paper for determining equilibrium moisture contents with the high degree of accuracy on very small samples. He continued with a brief discussion of the concepts and theories of water absorption of pulps at various humidities.

Mr. Van den Akker commented briefly on the optical methods and techniques for estimating the bonded area of pulp sheets, based upon the relationship of sheet opacity to degree of beating.

The purpose of this discussion was to describe the techniques currently employed at the Institute for the determination of bonded area of handsheets. Following a description of the method, as evolved by Parsons, a recently encountered difficulty was described. (When the specific scattering coefficient s was plotted against beating time for water-formed and butanol-formed handsheets, the former, downward sloping curve intersected the latter, upward sloping curve at a point near zero beating interval. This situation revealed a hitherto unsuspected source of error, as it indicated the impossible situation of negative bonded area in the water-formed paper, at low degrees of beating.) It was shown by both theoretical considerations and experimental data that the wilder formation of the butanol-formed sheets was responsible for the difficulty. The difficulty was eliminated and the associated error minimized by the procedure of water-forming all handsheets. Those handsheets which are to become unbonded sheets are obtained by successive replacement of the water, after formation from water on the wire, by successive applications of acetone and butanol.

This results in bonded and unbonded handsheets of nearly identical formation. The procedure for producing unbonded handsheets is now as follows. After the forming of a handsheet, the latter is carefully covered with uncreped Whatman's filter paper. With the water level in the leg under the mold at a point just beneath the wire, 500 ml. of C.P. acetone are carefully poured against the side wall of the deckle box; the value is adjusted so that the time of passage of the acetone through the combination of filter paper and handsheet is about 5 min. Second and third 0.5-liter volumes of pure acetone are passed through the handsheets, followed by three passages of 0.5-liter volumes of pure normal butanol. The filter paper is carefully peeled away from the butanol-saturated handsheet, a clean blotter is laid upon the handsheet, and the combination lightly pressed in the usual way with the couch roll.

After couching, the handsheet is pressed between blotters for 7 min. at 50 p.s.i. The combination of handsheet between blotting papers is then transferred to drying rings for removal of the butanol by vaporization. After determination of the absolute reflectances, R_o and R_o^1 or R_∞ of the bonded and unbonded sheets, the measured portions are stamped out with a circular die and these portions are immediately weighed on an analytical balance to obtain the basis weight W.

Most determinations in the past have been made at wavelength 600 mmu, because certain pulps such as unbleached kraft are much more transparent at this wavelength than at, e.g., the effective wavelength of papermaker's brightness.

J. A. Van den Akker, Institute of Paper Chemistry; R. J. Seidl, Forest Products Laboratory; W. A. Wink, Institute of Paper Chemistry; Unidentified; W. F. Luckenbach, Jr., Virginia Smelting Co.; H. W. Rowe, Nekoosa-Edwards Paper Co.; R. P. Whitney, Institute of Paper Chemistry; S. R. Parsons, Consolidated Water Power & Paper Co.; and L. A. Moss, Whiting-Plover Paper Co.

The question was raised as to whether one should employ specific bonded area, or per cent bonded area, and it was suggested that the choice depended upon the work at hand. For example, if the study involves the "z-tensile" (tensile strength in a direction perpendicular to the sheet), it can be shown to be more appropriate to employ the per cent bonded area. Incidentally, the obtaining of this quantity does not require standardization of the method through the determination of specific surface by the silvering technique.

Mr. Haselton described the technique used in his doctor's thesis work for determining the specific surface of pulps and papers by gas adsorption using the Brunauer, Emmett, and Teller equation. This technique is based on the principle that if the volume of an adsorbed gas required to cover a material with a film one molecule thick can be determined and if the cross-sectional area of each absorbed molecule is known, then it is necessary only to multiply the number of gas molecules by their average area to obtain the total accessible area of the solid.

It was pointed out that it was not until the development in 1938 of the Brunauer, Emmett, and Teller theory of multimolecular adsorption that the estimation of this monolayer volume was placed on a sound mathematical basis. This theory of physical adsorption, which is merely an extension of the familiar Langmuir unimolecular adsorption theory, today constitutes the most useful picture of the low-temperature adsorption of gases by solids. The various steps involved in measuring adsorption isotherms, plotting these isotherms according to the method of Brunauer, Emmett, and Teller, and employing these plots for determination of specific surface area were discussed.

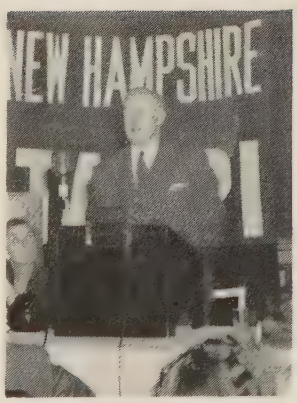
Research work presently being carried out on the adsorption of nitrogen, *n*-butane, and carbon dioxide on wood and pulp was outlined. Consideration was given to the areas of pulp and paper which were accessible for gas adsorption. Finally, preliminary data were presented to indicate that gas adsorption techniques may provide a tool for the investigation of the specific surface area of pulp fibers and especially the bonded area of paper.

I. A. Moss, *Secretary*
Lake States Section

Maine-New Hampshire

The Fall Meeting of the Maine-New Hampshire Section of TAPPI was held at the Lafayette Hotel, Portland, Me., on November 7 and 8. The Friday afternoon session was devoted to a consideration of several of the most modern phases of pulp bleaching. Arthur E. Jones of the Oxford Paper Co. and vice-chairman of the Section presided. J. J. Thomas of the S. D. Warren Co. was chairman.

J. J. Thomas, S. D. Warren Co.; H. S. Hooper, Penobscot Chemical Fibre Co.; R. G. Macdonald, TAPPI; J. B. Calkin, University of Maine; G. A. Day, Brown Co.; A. E. Jones, Oxford Paper Co.; W. L. Hinds, Keyes Fibre Co.; J. L. Parsons, Hollingsworth & Whitney Co.; and H. E. Pratt, Pejepscot Paper Co.



R. G. Macdonald, TAPPI

H. F. Szepan, Improved Paper Machinery Corp.

A dinner and dance with light entertainment followed in the evening. R. G. Macdonald, National Secretary-Treasurer of TAPPI, gave a short talk after the dinner.

One of the most interesting features of the two-day meeting was the get-together breakfast Saturday morning followed by a conducted trip through the new brown stock and bleaching plant of the S. D. Warren Co. at Cumberland Mills. At the breakfast, Alfred A. Mann of the Warren Co., outlined the trip and explained the tests and controls used in the new bleach plant to insure the best possible quality of hardwood pulp. He pointed out the importance of the addition of new plants of this sort to the economy of the United States paper industry.

The total registration for the meeting was 156. One hundred seventy-two members and guests enjoyed the dinner and dance. One hundred attended the Saturday morning breakfast before their tour through the Warren mill.

The first paper of the Friday afternoon session was "Bleaching Pulp with Chlorite," by Keith S. MacLeod of the Mathieson Chemical Corp. He described the various methods by which pulps have been successfully bleached with sodium chlorite and chlorine dioxide. This newest of chlorine bleaching agents has given excellent results with flax, cotton linters, rags, soda, sulphite, and sulphate pulps. Mr. MacLeod explained that sodium chlorite, when activated by chlorine or hypochlorite, can do a good job under alkaline conditions. He pointed out, however, that the best results are obtained when chlorine dioxide is applied under acid conditions. This, of course, requires special materials of construction. Several practical methods by which a mill can generate its own chlorine dioxide were mentioned, including those developed by Mathieson, Solvay, and the Brown Co. The value of chlorine dioxide lies in its unique ability to bleach cellulose fibers to a high brightness with a minimum loss of strength.

H. B. Channon of the Virginia Smelting Co. discussed the "Values of Acidic Reducing Agents in Kraft Bleaching." He explained how sulphur dioxide can sometimes be successfully used for bleaching in cases where conventional oxidizing agents fail. He illustrated with charts the benefits to be derived from the use of sulphur dioxide as a "super bleach" in the case of chemical pulps. The use of as little as 8 to 10 lb. SO_2 per ton of pulp can often result in an increase of 2 to 2.5 points in G.E. brightness. At the same time color reversion on drying and storing is almost eliminated.

The third paper was "High Density Hydrogen Peroxide Systems" by R. L. McEwen of Buffalo Electro-Chemical Co., Inc. Mr. McEwen pointed out that with modern mechanical techniques, it is possible to bleach with hydrogen peroxides at stock densities of from 20 to 50%. One value of such high densities is a considerable chemical cost reduction. Dia-

L. McEwen, Buffalo Electro-Chemical Co., Inc.

A. A. Mann, S. D. Warren Co.

grammatical sketches of suitable equipment were shown. Hydrogen peroxide bleaching has been successfully applied to semichemical and groundwood pulps. He stated that work now in progress indicates that it may be of real value as a super bleach for soda, sulphite, and sulphate pulps as well.

The final paper of the afternoon was by Henry F. Szepan of Improved Paper Machinery Corp. who described "Modern Washing and Bleaching at S. D. Warren Co." By means of pictures and flow sheets the sequence of brown stock washing, screening, and bleaching was followed from the digester blow tank to the bleached pulp storage chests.

The new Waco filter system, installed to provide processing water for the new bleach plant, was also described. This was one of the first installations of this type of filter in this country for treating raw water.

Mr. Szepan pointed out that this new washing, screening, and bleaching system, for which most of the equipment was designed and built by IMPCO, is one of the newest and most modern in the country. Those who visited this plant the next day agreed that it was well planned and engineered for the production of high quality soda pulp; particularly outstanding were the remote controls and recording instrumentation.

T. H. Werner, W. V. Torrey, and W. H. Marra
S. D. Warren Co., Cumberland Mills, Me.

Modern Washing and Bleaching at S. D. Warren Co.

H. F. Szepan

One of the highlights of this Maine-New Hampshire Fall meeting is a tour through the new pulp mill at the S. D. Warren Co. This talk will endeavor to give you a preview of the flow sequence of the new continuous pulp washing, screening, and bleaching systems with emphasis on the various pieces of pulp handling equipment.

The S. D. Warren Co. manufactures soda pulp and plain and coated papers. The first operation began nearly 100 years ago at the Cumberland Mills plant which is situated on the Presumpscot River. Many cycles of expansion and modernization have changed the plant from an operation producing $1\frac{1}{2}$ tons per day of rag papers to its present daily capacity of 240 tons of soda pulp of which 190 tons is hardwood and 50 tons is pine. Some outside pulp is purchased so that the paper mill produces 425 tons of finished papers both plain and coated. In the most recent cycle of plant modernization since the beginning of World War II, major steps were accomplished to bring the methods and equipment in the paper mill, power plant, filter plant, wood room, and pulp mill up to date.

The new pulp washing and bleaching building is one of the finest constructions of its kind in the country. The layout of the process equipment and its controls incorporates the engineering advances learned in planning numerous installations since the last war. The Improved Paper Machinery Corp. is proud of the fact that it had an opportunity to collaborate with the J. E. Sirrine Co. of Greenville, S. C., who were the consultant engineers on this project, and the fine engineering staff of the S. D. Warren Co. in planning the installation arrangement of the washing and bleaching equipment.

The new fireproof building, completed in the Fall of 1951, is 70 ft. wide, 105 ft. long, and 90 ft. high. The entire building is under a system of forced ventilation providing fresh filtered air which is heated as required.

The brown stock washing system is located along one side of the building, and the bleaching system along the opposite side. Hood exhaust fans remove chemical odors from both systems and there is no dividing wall separating the two process operations. On the operating floor, a line of three 8 by 16-ft. countercurrent black liquor vacuum washers parallels three 8 by 16-ft. tile vat bleach washers. Floor space has been left for a future washer addition to either system, and in one corner there is a large enclosed area used as a control laboratory.

BROWN STOCK WASHING

Let us take a closer look at this modern rotary drum washing system which gives some very important advantages over diffuser type of washing. Some of the advantages are:

1. Closed system with no sewer losses and hence reduced stream pollution.
2. Less labor.
3. Low maintenance.
4. Less dilution of black liquor.
5. Low heat losses.
6. Greater flexibility in rate of production.

The stock washing system immediately follows the digesters and the first unit in the washing system is the blow tank. This tank is of standard design and has a cone bottom in which a vertical adjustable pitch propeller agitator is located to mix in a comparatively small zone the blow-consistency stock with dilution liquor to a reduced pump-out consistency. The blow tank serves not only as a surge tank between the batch cooking process and the continuous process, but also as a high density storage tank.

About nine years ago, the instrument manufacturers worked out a dilution control system whereby the action of a wattmeter air controller actuated from the agitator motor power requirement operated the dilution valve pneumatically. With this type of device, the stock in the bottom of the cone is maintained at a uniform pump-out consistency close to 3.5%.

From the blow tank the stock passes through a tramp iron trap and then flows through a Venturi tube located in the

Inspecting the console control of the brown stock washing and bleach plant of the S. D. Warren Co.

H. F. Szepan, Sales Engineer, Improved Paper Machinery Corp., Nashua, N. H.

stock line. Differential Venturi pressure is transmitted to a receiver which acts to position an automatic valve to give the desired flow of stock to the vibratory deknotters located 60 ft. above the ground level.

Before the stock enters the vibratory deknotters, it is diluted to a $1^1/_2\%$ consistency. The vat of the deknotter is designed for direct connection to the first washer. Special vibration mounts under the vat isolate any vibrations set up by the unbalanced weight-type drive from the building. The 16-ft. wide deknotter is equipped with two 56-in. baskets and one 44-in. basket having 63.5 total sq. ft. of effective area. The primary plates have $^1/_2$-in. perforations and the ramp plates have $^3/_8$-in. diameter perforations. The knot-collecting conveyor discharges the knots to one end where they drop into a chute and are flushed to disposal.

The deknotters feed directly into a line of three 8-ft. diameter by 16-ft. face vacuum filters with interstage repulpers. The line of washers, repulpers, and deknotter are welded together to form a single unit. The entire line is fastened to the building steel only in two places; one point midway on each side of the line, thus permitting fore and aft expansion movement from the midsection.

The washer vats are "floor" mounted which gives a convenient operating height all on one level without the need of platforms. This gives an installation which offers freedom from dripping below, and hence from "double wash-ups," and less expensive piping because it is all carried up from below the floor. A hood exhausts the vapors from the entire washing line to the atmosphere. The washers are of welded steel and stainless steel design and construction and similar to those in over 60 such installations which daily wash thousands of tons of stock each day.

Instead of take-off rolls, these particular washers are equipped with "micrometer" adjustment take-off doctors which permit precise clearance setting. This method of take-off works very well on short fibered pulp.

The intermediate repulpers between the washing stages also have vats designed so that the steel weldments are box-sectioned like the washer vats to present a smooth, easily maintained exterior surface not ribbed or flanged.

There are two repulper rotors—a large diameter slow speed top rotor to pull the stock under the surface and saturate it with liquor, excluding air as far as possible, and the lower rotor operating at a high speed to give thorough mixing and scrubbing.

The weak, intermediate, and strong black liquor seal tanks are located outside of the building. The location of the foam tank is somewhat unusual in that it comes up through the center of the strong liquor tank. This is a feature which was worked out to save space. A mechanical foam breaker sits on top of this foam tank to break down any excessive foam. All of these tanks are covered with insulation material to retain the heat of the liquor.

On the tending side of the washers, a large instrument console permits easy liquor and shower water flows, liquor manually controlled through remote operated valves, shower water automatically controlled by flowmeter consotrols. Individual filter speed controls, auxiliary gages, pushbuttons, air meters, etc., are concentrated in this console cabinet.

The washing system is rated at 235 air-dry tons per day. To date, the hardwood cooking schedule has been averaging 190 tons. At this production rate, the chemical loss is 15 lb. (expressed as Na_2CO_3) per ton in the cake off the final washer. The Baumé of the strong liquor going to the evaporators is around 9.2° at 185°F. The temperature of the fresh water showers on the last stage is kept at 160°F. (varied from 120 to 160°F. depending on season and volume demand).

The discharged mat off the third and final stage washer is shredded as it drops into a washed stock high density storage tank having a capacity of 35 tons at 12% air dry. This tank has a cone bottom with a vertical blow tank-type agitator and automatically controlled dilution. Screen room white water is used for diluting the stock to pump-out consistency.

PULP SCREENING

From the high density storage chest, the pulp is pumped to a battery of five centrifugal screens located in an adjoining building. Rejects from these screens are handled over three IMPCO 14-plate bronze vat flat screens arranged in series. The accepted stock is thickened on a 6-ft. 6-in. diameter by 16-ft. face IMPCO valveless-type vacuum decker and discharged into a tile storage chest preparatory to bleaching. The white water from the decker is returned to another tile storage chest for use as dilution. Carefully planned instrumentation in both the screen room and washer room enable the brown stock washer operator to take care of the screening as well as all the washing.

Before proceeding with the bleaching sequence it would be worth while to describe the operating principle of the screen-room decker. This valveless vacuum-type filter is gaining wide popularity, and over 200 such machines have been sold both in this country and abroad for pulp thickening and washing purposes.

This machine was developed in Sweden by the Swedish Cellulose Co. and is being manufactured in this country by IMPCO under license in 6-ft. 6-in., 9-ft. 6-in., and 11-ft. 6-in. cylinder diameters. The width of face in the respective diameters starts at 8 ft. and continues to 16 ft. in 2-ft. increments.

The outer part of the drum construction, namely the face, supporting winding wire and ribs, is very similar to that on a vacuum filter. On a 6-ft. 6-in. diameter drum there are 18 circumferential sections dividing the cylinder into 18 longitudinal vacuum divisions (compartments) each extending the full length of the cylinder. The 9-ft. 6-in. diameter drum has 21 such longitudinal divisions, and the 11-ft. 6-in. diameter drum has 30 divisions.

Here, however, the similarity to a regular filter stops. At a point somewhere along each longitudinal division there is an outlet at the bottom that feeds into a "canal or duct" which is formed by an inner wall of the cylinder, extending backward from the division a third of the way around the inside of the drum. The trailing end of this canal is open into the interior of the drum. The canal actually serves as a moving, short barometric leg.

Perhaps the easiest way is to trace the operation. As a typical leg, the drum, position 1 enters stock submergence in the vat, there is a flow of liquid through the wire into the respective compartment concerned. This filtration is all by gravity—no vacuum—and since the canal extends upward in this position, it acts as an air vent. As the cylinder rotates, position 2, more and more pulp is deposited and more filtrate accumulates in the compartment. About halfway through the rotation the compartment begins to ascend, and when this occurs, the outlet from the canal (which lags its respective compartment by about one third of the revolution) is sealed in the liquid which is in the interior of the cylinder. As soon as the compartment elevation goes above the inside liquid level, position 3, the filtrate in the compartment starts to discharge through the moving leg by gravity. A vacuum starts to develop which reaches a maximum of about $3^1/_2$ in. Hg in the 6-ft. 6-in. diameter cylinder and slightly more in the larger diameter filters.

When the compartment under discussion passes the cylinder top center line, the leg outlet emerges above the liquid level inside the cylinder. As the filtrate flow out of the canal diminishes, a back flow of air breaks the vacuum in the compartment, thereby releasing the hold on the pulp mat just ahead of the take-off device.

While the vacuum is not as high as on a vacuum filter, discharge densities from 9 to 12% are being obtained on chemical pulps without the use of press rolls.

One end of the cylinder is deckled to allow effluent discharge from the drum interior. An outstanding advantage of

this valveless filter is that it does not require any vacuum pump or barometric leg. This permits installation at any mill elevation, thus considerably reducing the effluent repumping load as well as material for building construction. The absence of a vacuum timing valve reduces the amount of mechanical maintenance which vacuum filters sometimes require.

PULP BLEACHING

The bleaching operation at S. D. Warren is carried out in three continuous stages—chlorination, caustic extraction, and calcium hypochlorite. Space has been provided for a future addition of another bleaching stage.

Since 1933, when the rights were obtained by IMPCO to manufacture continuous bleaching equipment in this country under the Thorne and the Baker patents, considerable experience has been gained from the many bleacheries which have been designed and built. Much has been learned in the design of bleaching equipment and economical sequences to produce pulps of the highest brightnesses with minimum loss in strength and minimum chemical usage.

In modern day bleaching, it is very important to have good pulp washing after each separate process. Any impurity rendered soluble must be removed by washing if we are to take advantage of having it soluble. If it is not washed out, it must be removed later by destruction in the bleach stages. Additional chemicals are necessary to do this and not only are these expensive, but they also endanger the pulp strength. When washing is not thorough at the end of the bleaching process, the residues in the bleached pulp are certain to cause color reversion of the pulp or paper on aging.

The flow process in the bleach plant commences with screened brown stock being pumped from the tile decker storage chest up through a feeler-type consistency regulator at 4.6% and then through a variable speed volumetric stockmeter. From here the pulp drops to the ground floor level and passes through a rubber-lined wabble plate chlorine mixer before the stock flow divides equally into two up-flow chlorination towers operating in parallel. Since S. D. Warren has an electrolytic plant the manufactured chlorine gas is first dissolved in water before it is admitted to the stock at the chlorine mixer as chlorine water. The quantity flow of chlorine water varies from 100 to 400 g.p.m. which makes it necessary to maintain a higher consistency through the stockmeter to keep the proper consistency in the towers.

Chlorination takes place in two 16-ft. diameter by 48-ft. high steel tile-lined towers. Each tower has a vertical rubber-lined impeller type of agitator extending the full height of the tower with an overhead drive arrangement. These towers, at $3^1/_2$ % consistency, provide for a total of 90 min. retention time at rated production. From the tower launders, the chlorinated stock is pumped to a rubber-covered vacuum washer-thickener. Following washing and thickening, the stock passes through a high density double shaft mixer where caustic is added and drops into a 14-ft. diameter by 37-ft. high tile-lined caustic tower providing 120 min. retention at 12% consistency.

In the caustic tower, the stock flow is downward and the discharge is accomplished by a cast steel scraper assembly and twin metering discharge screws having a variable speed drive. These screws deliver into a dump chest equipped with a screw type agitator where the stock is diluted to 3% consistency. From this chest, the stock is pumped over the caustic washer-thickener and then goes through the hypo mixer and into the hypo tower. This steel tile-lined tower is ft. in diameter by 37 ft. high and provides 200 min. retention at a consistency of 12%. The arrangement of the mixer, tower, dump chest, and the mechanical agitating and delivery equipment is the same as for the caustic tower. After a final washing on the hypo washer, the stock passes through a pan-type consistency regulator and is pumped to a $3^1/_2$% stock storage chest.

The bleach vacuum washers are 8 ft. in diameter by 16 ft. face and are all set in tile vats. Each washer has an individual, close fitting hood arrangement so that the chemical fumes are contained and exhausted to the atmosphere.

To carry away the dissolved natural organic matter and concentrated chemical residuals from each stage of washing, approximately 50,000 gals. of fresh water is used per bleached ton of pulp. This fresh water enters the bleaching system as shower wash water on each washer and also through each cylinder wire cleaning shower. The remaining balance is split equally so that one half enters the hypo stage seal box and the other half enters the caustic seal box with the points of entry such that this fresh water always has preference to the suction of the filtrate pumps serving the washers. All the overflow from the hypo seal box flows by gravity to the chlorination seal box and is used as dilution ahead of the chlorination washer. The caustic stage overflow goes directly to the sewer and is never used as recycled white water on the chlorination stage because chemical precipitation takes place and the precipitate causes serious blinding or plugging of the face wire.

The seal boxes are quite large to allow the greatest amount of filtrate retention prior to recycling so that as much deaeration can take place as possible. The trend today is toward larger seal boxes which will give 2 or 3 or more minutes' retention time before recycling, since it has been proved that the capacity of a washer, as well as its performance, can be reduced as much as 50% by the minute air bubbles in the aerated stock which slows down the filtration rate. Each seal box is vented directly to the foam tower. This foam tower is 42 ft. high and 6 ft. in diameter, having a U trap sump seal at the bottom to reduce the amount of foam carried to the river through a 24-in. diameter vitrified clay sewer pipe.

The brightness of the bleached soda pulp is held to a 74 to 76 G.E. color and this is governed by the paper mill requirements. One operator is in charge of the operations with an assistant performing routine sampling and making necessary control laboratory tests.

WATER FILTRATION PLANT

To insure an adequate supply of filtered process water for the bleach plant, a new filter plant was installed. Though the process demand is approximately 10,000 g.p.m., a plant having 15,000 g.p.m. capacity was erected to allow for expansion and to immediately provide a flow of 5000 g.p.m. into the present filtered-water system as a booster.

A new 42-in. pipe line approximately 200 ft. long was laid across a portion of the river bed to allow gravity flow into the new plant. The intake of this line is screened to filter out coarse material, leaves, etc. The water filters and pumps are housed in a new building of concrete, steel, and wood construction. A concrete water storage basin is included in the basement of an adjoining building.

Three mechanical-type Waco filters, each 6 ft. 6 in. in diameter by 14 ft. face, set in a common concrete vat, do the filtering. These filters are of the precoat type using pulp on a traveling wire as a filtering medium and incorporating the laboratory principle of separating suspended solids from a liquid by the use of a cellulose filter paper. The speed of the three filters is automatically controlled by the level of water in the clear water storage basin.

Under normal river conditions, each filter clarifies about 5000 g.p.m. of raw water at a wire speed of about 2 in. per min. Normally, 100 lb. of pulp is consumed daily as a filtering medium. This pulp, together with the retained dirt particles is discarded since it is not economically feasible to reclaim such a small quantity for use as secondary pulp.

SUMMARY

Based on the opinions of people who have seen many recently built pulp mills, it is generally agreed that the new plant is one of the best of its kind in the country.

Empire State

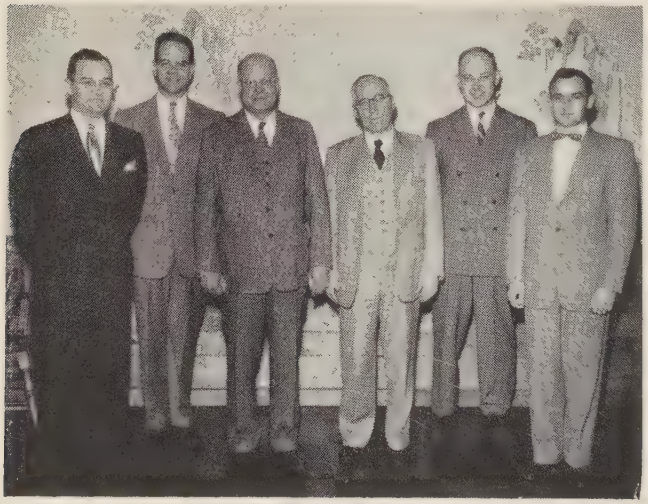
Central District

The November meeting of the Central District, held on November 11 at the University Club, Syracuse, N. Y., was opened by the chairman, H. D. (Doc.) Cook, reading a letter from Prof. Libby, retired past-chairman of the District and now at the North Carolina State College at Raleigh, N. C. Prof. Libby also included some views on the judging of technical papers given in competition by the Empire State Section. The chairman also introduced the members of the head table: Profs. Hitchings, O'Neil, and Jahn from the College of Forestry, H. M. Gray, Oswego Falls Corp., Ernest Reed, Syracuse University, and Ralph Prince, Secretary-Treasurer of the Section.

Mr. Gray then introduced Durward Geffken by briefly pointing out the natural concern of the paper industry with the state's program for stream pollution control. Mr. Greffken spoke on "Evaluating the Quality of Oswego River Water" and illustrated his talk with maps of the area. A summary of his remarks follows:

In the last 20 years much has been accomplished in pollution control in New York State. Present interest in the water quality of central New York has been heightened by plans for a City of Syracuse sewage plant, a State plan for the reclamation of Onondaga Lake, especially the west side adjacent to the fairgrounds, and consideration of Oneida Lake as a means of augmenting the water supply of Syracuse.

In 1946, the New York State legislature passed a bill which provided for a committee to study the water pollution problem. In 1949 the New York State Comprehensive Water Pollution Control Law (Article 6 of the Public Health Law) was enacted. Its policy was to maintain reasonable standards of water quality consistent with maintaining industrial activity by the use of all known and reasonable methods. A Board was established to regulate the existing water pollution and prevent new pollution. The Board consists of the Commissioners of Health, Conservation, Agriculture and Commerce, and Public Works, with A. F. Dappert appointed Secretary by the Board. By this means a program of developing classification standards was initiated. The classification which emerged from questionnaires and open hearings was as follows: Class AA—highest quality, for drinking or food processing after disinfection; A—drinking or food processing after coagulation, sedimentation, filtration, and disinfection; B—bathing; C—fishing; D—agricultural and industrial supply; E—sewage and industrial waste disposal and transportation; F—sewage and industrial waste or waste disposal only. Class B and above require no floating debris or sewage, pH = 6.5 to 8.5 minimum dissolved oxygen 5 p.p.m. (4 p.p.m. for nontrout waters). All classifications may apply to different parts of a large body of water. Onondaga Lake, for example, is temporarily classed B, C, and D. It is expected that the classification of all waters in the State will require about 15 years depending on the size of the staff available.



R. N. Prince, American Cyanamid Co.; S. Earll Church, College of Forestry; H. D. Cook, Sweet Bros. Paper Co., Inc.; H. M. Gray and D. B. Geffken, Oswego Falls Corp.; and R. G. Hitchings, College of Forestry

R. N. Prince, American Cyanamid Co.; E. C. Jahn, College of Forestry, State University of New York; H. M. Gray, Oswego Falls Corp.; H. D. Cook, Sweet Bros. Paper Co., Inc.; Ernest Reed, Syracuse University; D. B. Geffken, Oswego Falls Corp.; and F. W. O'Neil and R. G. Hitchings, College of Forestry

In July and August of 1951, a group of paper mills decided to investigate the Oswego River in cooperation with the New York Section of the National Council for Stream Improvement. The Oswego River drains an area of 5100 square miles extending to almost Rochester in the West, Rome in the East, and below Ithaca in the South. It is part of the Barge Canal system and all of the fifteen lakes except Cayuga, Skaneateles, and Canandaigua Lakes are controlled for canal transportation purposes. The portion investigated has a drop of 120 ft. from Three Rivers to Oswego. The flow of water is large and variable, usually between 900 and 2600 cu. ft. per sec. at Oswego.

The samples were tested for temperature, dissolved oxygen, alkalinity, pH, suspended solids, and chlorides.

On the basis of this study, the river appeared to be class C without sewage plant installations. It could not rate higher than B because of the high chlorides content. Paper mills in the area could meet class B if they exercised care in disposing of heavily dyed water and pigments.

References were made to *Health News*, a publication of the New York State Public Health Department, and an article by J. F. Baigas in *Tappi* 35 No. 1: 118A (Jan., 1952).

In the discussion which followed, Chairman Cook pointed out that from his experience he considered fluctuations in water flow in the Oswego River responsible for variations in hardness and 200 to 600 p.p.m. of chlorides. The flow fluctuations may be caused by winds on Onondaga Lake and by the Caughdenoy Dam control of the Oneida Lake level. Dr. Ernest Reed contributed his opinion that the river cleaned itself by natural means in a distance of 7 miles.

S. Earll Church, *Secretary*

Empire State

Northern District

Seventy-five members and guests of the Northern District of the Empire State Section of TAPPI attended the second monthly meeting held at the Hotel Woodruff on Thursday, Nov. 13, 1952. A panel discussion was held on "The Legislative Aspects of Forests in New York State."

Assemblyman Benjamin Demo was the moderator with State Senator Henry A. Wise, Watertown, and Assemblyman Orin S. Wilcox, Theresa, members of the panel. All other aspects of the discussion were overshadowed by the importance of the Panther Mountain Reservoir project to the pulp and paper industry in this section of New York State. It is the consensus of opinion of the legislators attending that the one big job is to teach the people the benefits which they shall receive from Panther Mountain Reservoir as contrasted to the benefits a limited few will receive by not having the reservoir. The teaching job should be a part of our everyday activities. Maps showing the extent of the forests taken over since 1893 by the State were posted. A lively question-and-answer session followed a few words of introduction by each legislator.

Richard J. Murtaugh, *Secretary*

Empire State

Eastern District

A sound and color film on "Corrosion in Action" was shown at a dinner meeting of the Eastern District of the Empire State Section of TAPPI on Nov. 20, 1952, at Milfranks Restaurant, Glens Falls, N. Y. Introductory remarks were made by Herbert O. Teeple of the International Nickel Co., New York, N. Y.

The three-part film, issued by the Development and Research Div. of the International Nickel Co. opened with examples of the economic importance of corrosion, illustrating several forms in which corrosion damage can occur. A short history was portrayed of the development of the electrochemical theory of corrosion and the contribution made to it during the last 125 years.

A practical illustration was shown of the control of corrosion by elimination of oxygen in steam plant boiler water by deaeration equipment. The phenomenon of metals which can replace others in solution and the effects of galvanic action were demonstrated by experiments, parts of which were shown in animation.

The passivation of iron by exposure to concentrated nitric acid was demonstrated as well as how the addition of chromium and nickel provides a more stable passivity. The importance of avoiding local shielding of stainless steel surfaces so as to induce local loss of passivity was illustrated as well as practical examples of damage that results from these effects.

The film closed with illustrations of several steps that may be taken to avoid corrosion and the advantages that may be derived from a scientific approach to the solution of corrosion problems.

A question-and-answer period, conducted by Mr. Teeple, followed concerning the application of the principles in the film to the pulp and paper industry. A question on the passivity of stainless steel was answered with an illustrated use of stainless steel in a sulphite digester wherein localized attack occurred under a deposited calcium sulphate scale.

This was an application of the principle of oxygen-concentration cell corrosion. A similar illustration of this type of corrosion was cited in respect to pulp fiber build-up on stagnant areas of stainless steel equipment.

The film was procured by Charles J. Hannan of the Whitehead Metal Products Co., Inc., in Scotia, N. Y.

CLYDE DAVIS, *Publicity Chairman*

Empire State

Western District

The Western District of the Empire State Section met at the Prospect House in Niagara Falls, N. Y., on Nov. 5, 1952. The principal address was given by H. A. Rothchild, Vice-President of the Kimberly-Clark Corp., Neenah, Wis. Mr. Rothchild's talk follows:

J. Perry, Waste Paper Utilization Council; State Senator H. A. Wise; J. H. Treadwell, Treadwell Supply Co.; D. Parmele, St. Regis Paper Co.; Assemblyman O. S. Wilcox; R. A. Premo, Gould Paper Co.; Assemblyman Benjamin Demo, and R. J. Murtaugh, St. Regis Paper Co.

R. N. Prince, American Cyanamid Co.; R. M. Drummond, International Paper Co.; C. J. Hannan, Whitehead Metal Products; R. E. March, Marinette Paper Co.; H. O. Teeple, International Nickel Co.; Grant Cole, Diamond Match Co.; and Clyde Davis, Finch, Pruyn & Co., Inc.

Stream Pollution

H. A. Rothchild

LIMITED time does not permit any detailed discussion on stream pollution because there has been so much work done and so much publicity given, that we would not finish with any one branch of the subject in one evening. Legal aspects alone would warrant several days of symposium to say nothing about the aesthetic, public health, conservation, and other technical aspects too broad to go into in any detail. I propose to cover most of the phases once over lightly, because I do not know your primary interests.

Taking the legal aspects first, we will look at the current applicable laws. I specify current and applicable laws because public health laws were enacted in the United States as far back as 1898 and many of these old laws could be construed to apply to paper mills where it is charged that the effluent from a paper mill affects public health. We will limit ourselves to current legislation because of time available.

New York law defines pollution as the discharge of material into a water system to cause the water to fall below standards set for it by the Water Pollution Control Board. In other words, you are guilty of polluting a stream in New York State if you discharge material into it that causes it to fall below the standards.

Let us suppose you are one of several industries on a stream, or you are one of two or more industries along with a number of municipalities. The first question which arises, in interpreting this law, is which mill or municipality is guilty of pollution.

It is possible that one or more mills or municipalities could discharge their wastes into a stream without causing it to fall below standards set for it. But the accumulated effect of wastes from all the industries and municipalities can be too much for the recovery powers of the stream and it falls below standard.

The New York Control Board is what is popularly known as a commission form of government. Your board would probably make a thorough survey of the stream and all contributions of pollution to it. Suppose the board found that total pollution would have to be cut 50% in order to bring the stream back to the classification set for it. The simplest way would be to order every polluter on the stream to reduce his pollution contribution 50%. That may be impracticable and in some cases illegal.

For example, your New York law does not allow the board

H. A. ROTHCHILD Assistant to Mfg. Vice-President, Kimberly-Clark Corp., Neenah, Wis.

to issue orders impossible for municipalities to comply with because of statutory restrictions on borrowing power. Nor does it permit orders impossible for industries to comply with because of no known adequate method of treatment. Because of this, some contributors to pollution on the stream may be freed of an order. It also is most probable that some contributors already have made progress in abating pollution while others have done little, and it would be unfair to order both to abate their pollution by the same percentage of their present contribution. Therefore, before the board can issue a reasonable order of abatement, it will have to make a thorough survey of the stream and all pollution in it. Methods and techniques used in making such a survey will be discussed later when we talk about technical aspects.

Your New York law is quite similar to the laws of the other states that have enacted stream pollution legislation. Wisconsin does not have "stream classification" but does have a commission form of government similar to your control board. Wisconsin law defines pollution as "the contamination, or rendering injurious or harmful to public health, commercial or recreational uses, or deleterious to animal or plant life."

From my experience, I do not believe it makes any difference to us papermakers whether we are operating in a state with or without stream classification. Advantages and disadvantages balance out. Penalties in New York are stiffer than in any of the other states that come to mind. They are, in brief, $500 fine and $100 per day and $10 per each fish killed. The $500 and $100 fines are not too serious, but the $10 per each fish killed can give you a jolt. Remember that a fingerling minnow counts as one fish just as much as a big pike or bass and I have seen several fish kills where 3000 dead fish could be counted in the back waters and weeds along the stream. That is equivalent to $30,000!

There also is a penalty for willful violation of $100 and $500 and/or 1 year in the cooler, but you technical people need not worry because directors and officers represent a corporation in violation cases.

Seriously, however, penalties mentioned have hardly ever been used in states where similar pollution laws have been in force for a number of years. Our experience has been that the committees similar to your board are made up of fair-minded, hard-working individuals, and while the most severe penalties occasionally have been invoked, it has only been in cases where repeated past warnings have been ignored.

I believe one improvement that could be made in the laws of both New York and Wisconsin is in the personnel of the control board. Your board includes commissioners of departments of health, conservation, agriculture and markets, commerce, and the superintendent of the department of public works. Most states which recently enacted pollution laws have provisions for membership on the control board of representatives of industry, municipalities, and conservation or one or two of these three. The Federal law enacted in the 80th Congress sets up a 12-man board of six government and six nongovernment men.

It is my belief, based on past observation, that pollution control boards or committees now composed only of state employees would profit if they included additional representatives of nonstate employees, practical men equipped with first-hand information on industrial, municipal, or conservation problems. These practical men sitting in top level decision meetings would give added strength to these boards.

I take this much time on legal aspects of stream pollution because I believe that technical men would do a better job of advising about pollution abatement responsibilities if they had a better understanding of the laws involved. I have observed that most corporations, although well posted on most of their legal obligations, such as labor and contract law, are poorly informed on pollution law and they depend on their technical men to head up antipollution activities for them.

Those of you from across the river undoubtedly know that the Ontario Lakes, Rivers, and Improvement Act was amended in 1949 as a result of the K.V.P. injunction suit at Spanish River in 1948. Formerly, a Canadian judge was forced to issue an injunction against a defendant polluter found guilty. Now under the amendment, he may issue an injunction or refuse one, or order certain abatement action. This was a tremendous relief to those of us who operate mills in Ontario, and are often the sole employers in a given area, because, unless an injunction can be lifted, the only recourse is to shut down the mill.

I can't leave this legal business without mentioning the complications for some of you here, who are on an international or boundary stream just as some of our mills out west are on interstate streams. The complication arises because you may be subject to more than one control board or commission. In addition to your state board, there are: The New England New York Interstate Water Pollution Control Commission, The President's Water Resources Policy Commission, The Interagency Committee in the Northeast, The International Joint Commission of U. S. and Canada on the Pollution of Boundary Waters, and several others.

All of these affect your future activity, especially if you are on an international boundary stream or interstate stream. The American Pulp and Paper Association and the National Council for Stream Pollution have done an excellent job in keeping your mills posted on activities of these various commissions.

It may be that the Canadian Pulp and Paper Association is doing an equally thorough job but I have not been in a position to judge its activity.

My best advice to you is try to keep at peace with all of them. If a state and a federal agency become competitive over which takes jurisdiction over pollution from your mill, or if two or more commissions fail to agree, and if the Province of Ontario or the Dominion government also gets into the picture, you will most likely be caught in the middle and become a political football. You should use your best efforts to keep all the agencies and commissions at peace with each other.

Let's move to the technical phases of stream pollution. It is noted that your New York board classifies streams by their condition in respect to floating solids, pH, D. O., toxic wastes, sewage, odor, etc. I find no mention of biochemical oxygen demand (B.O.D.) which is so generally used in sanitary engineering work, or of biological analysis, although both are discussed and used in the survey of international boundary waters by the International Joint Commission.

B.O.D. and biological analysis are two methods used extensively in making a stream survey where there is accumulated pollution, or where a number of mills and communities jointly pollute a stream. Before any board can issue a fair and reasonable order to bring any stream back into its classification, it must know the polluting effect of each waste. It must know the effect not only at the time waste enters the stream but the delayed effect down stream hours or days later. From the standpoint of oxygen balance, B.O.D. (5-day) is the most common measurement used for pulp and paper mills in determining this delayed effect. It is a poor test but the best we have. It is a test that technicians can argue about all night without agreement. Fortifying elements in the dilution water, effect of temperature, and in particular, the interpretation of results to the stream under study are seldom agreed upon. Details of the test are too time consuming to be included in this general talk.

A stream pollution contour survey is usually necessary in determining the composite effect of a number of mills and municipalities on a stream. The usual routine is to start far enough up stream so that the first sample point is above any man-made pollution, and then establish frequent sampling points down stream, so as to obtain tests above and below every source of pollution. Sampling and testing each point should be done once or twice a week for a period of 3 to 6

weeks. This 6-week sampling period should take place during that time of the year when the stream flow is at a minimum. Depending on local conditions, a sampling period in the Spring and Fall may be advisable, and in cases where pollution under the ice is in question, it should be repeated in the Winter.

The water at each sampling station is tested for D.O., B.O.D., pH, phenolphthalein alkalinity, turbidity, etc. Notice must be taken of the weather . . wind, sun, algae growth, air temperature, and any other unusual physical conditions noted in the water. A biological survey should go hand in hand with the chemical and physical testing. The water should be sampled with a plankton net and plankton counts made and the stream bottom sampled with a biologist's dredge to determine the nature of organisms inhabiting the stream bottom since they give an excellent check on the degree of pollution as shown by chemical tests. As a matter of fact, one of the best procedures to determine the degree of pollution of a stream from its source to its outlet or from one year to another is to use as an index, an organism, whether plankton or bottom, plant or animal, which is abundant in the stream and which is sensitive to environmental changes.

Fish population counts are sometimes made, but this is not usual with routine surveys. They are difficult and time consuming and not too reliable unless rechecked many times. All of this chemical, physical, and biological data plotted against the distance down stream from the first sampling point give a graphic picture of an increasing degree of pollution the river assumes in its course, of recovery points because of water rapids or aeration, of immediate effect of pollution added at given points or of delayed effect of pollution with high B.O.D.

I have noticed that the inexperienced technical man making a river survey frequently neglects to take complete notes on sunshine, cloudiness, wind direction and intensity, and other physical conditions during his survey. This is generally more important in a lake survey than in a stream survey, and more important in the Fall of the year than at other times. As you know, living growing water plants, weeds and algae consume carbon dioxide and give up oxygen to the water in the presence of sunshine. The tonnage of vegetation per acre of our water covered area is comparable to that of our dry land area with equivalent temperature and fertility, so the amount of oxygen given up to the water by growing vegetable matter in temperate lake water with a bright sun shining is very considerable and will give a very considerable increase in the test for dissolved oxygen in the water. On the other hand, at night the water plants consume oxygen due to their respiration processes, and there is a tendency for the dissolved oxygen to decrease at night.

One of our Wisconsin mills is located on the outlet of a rather large shallow lake and I have sampled this on a bright, sunshiny day in the Fall and found a supersaturated test of dissolved oxygen, only to find a dissolved oxygen of 4 to 5 p.p.m. a day or so later when it was cloudy and overcast. This drop was not only because of lack of metabolism of plants because of an overcast day, but was undoubtedly exaggerated by the using of oxygen in the water in the decay of some of the vegetation which had reached maturity and died, as it does in the Fall of the year.

Water weeds and algae, of course, grow and flourish in the Spring and Summer, dying and decaying in the Fall and Winter, just as is the pattern of our day land vegetation. This decay uses up oxygen from the water as the dry land decay uses up oxygen from the air. We have had several years when tons of fish would die from lack of oxygen in this lake in September. There is no industrial pollution in this lake to cause any lack of oxygen. The lack was due entirely to the decay of the natural crop of vegetable matter grown in the lake during the preceding Summer.

Yes, several people blamed the death of the fish on the paper mills although all paper mill sewers empty into the stream below a dam at the outlet of the lake. But then, the paper

H. A. Rothchild, Kimberly Clark Corp. and R. M. Drummond, International Paper Co.

mills in this area have been blamed for polio epidemics, watery eyes, swimmer's itch, and most every other ailment to which humans are subjected, so the blame for the fish kills was not unexpected although entirely unwarranted.

This tendency of some individuals to blame industries for abnormal occurrences in our water courses is characteristic of the antipollution agitation that has been, and is, currently, a popular topic with the public. It is developing into a kind of holy war against the corporate mill.

In order to hold your ground, it behooves you technical men to know more about your stream or water course, and the biology and chemistry of the stream into which your mill empties, as well as the nature of the material discharged.

For example, some years ago state officials and fishermen took us to task because we were losing 2 tons of fiber from one of our larger mills to the river each day. They feared spawning grounds on the river bottom would be ruined because the fiber would cover the bottom. It was even suggested that the fiber would clog the gills of fish, causing them to suffocate. Previously, we had made an extensive survey of the river and we pointed out to these people that there were over 100 moisture-free tons per day of fiber in the form of algae and other water vegetation being discharged into the river every day at this time of the year. It was coming from the lake up stream from our mill. Cynics among you will say "what good did it do you to be able to disprove their assertion about damage done by fiber discharged from the mill?" I agree to the extent that I realize as soon as our critics stop accusing us about one thing, they will start on something else. Nevertheless, I believe you are better off to be well informed so you can deny false accusations and limit your critics to the facts.

It is easier to sample and determine suspended solids in your stream than it is to sample your wire pit overflow or a car of pulp. Go out in a boat with a couple dozen quart jars. Take a sample about 1 ft. below the surface in shallow flowing water, and at about 4 ft. below the surface in deep flowing water. Sample at about 20-ft. intervals across the stream. Combine into a composite sample and filter a known volume through a Buchner. Dry and weigh the organic matter filtered out. Figure the pounds of organic matter per cubic foot of sample. From the nearest gaging station on the stream, get the cubic feet per second river flow and from this, calculate the pounds of organic matter per day passing down the stream.

It is almost a "must" in this day and age to have a complete survey of a stream before you start up a new mill. Then you will know what effect your new mill has had on the stream. We have followed this procedure for the last three new mills we have built in Ontario, Alabama, and Tennessee, collaborating through The Institute of Paper Chemistry with Canadian and Southern associates in making the survey. I read in the trade journals that many other diversified industries are adopting such a procedure as a standard practice.

We have sketched briefly some legal and scientific aspects of stream pollution. I would like now to go into more detail on the public relations phase of this problem. As mentioned, we are now, and for the last several years have been, in the grip of a sort of antipollution holy war campaign. The psychology of this is easy to understand. We are all in favor of conservation. We all want to preserve fish in our streams and the game in our forests and prairies. But because of short-sightedness of many industrialists who failed to adopt pollution abatement procedures available, and poor public relations which result, we have become the whipping boys of the antipollutionists, and many people believe that all pollution is willful and can be avoided. Many of the agitators against pollution are sincere and filled with righteous indignation against municipalities and industries that do not stop pollution.

I have often said that if I wanted to run for dog catcher or any other public office, I would run on a platform of antipollution. Everybody would be for it and nobody against it. Sort of like reducing taxes.

Now with the popular public support of this holy war on pollution, what is the best defense that we, as polluters, can put up? The answers are:

1. We must make a sincere drive to abate pollution in every case where methods are known, and to organize research and develop abatement methods where none are now known.

The National Council, the Wisconsin group, and the West Coast group are doing an excellent job on this. You should know, however, that there are certain local conditions in some localities where a mill may find itself in an embarrasing position when it immediately adopts all known abatement measures. Also, if you go into abatement measures of unknown value, you may not help pollution.

We all know that the record of these boards depends on their accomplishments—on how many orders they have issued and on how much money they have caused you to spend on abatement installations. It would appear sometimes that we find ourselves in a position where we may be damned by the general public if we don't do everything without being ordered, and damned by the boards if we don't leave something for them to order us to do.

Of course, if all industry had been diligent in abatement installations in the past, there would have been no aroused public opinion and no legislation establishing these boards. In other words, the fault is ours where past performance is concerned, but there is no use in going into that at this time; the boards already are with us.

I don't want to give the impression that the men on these boards are specimens with horns on their heads and hair on their tongues. By and large, they are as fine a group of men as you will find anywhere, hardworking, conscientious, and fair minded. Many a mill has been blamed for a fish kill or pollution mishap and has been pulled out of trouble by employees of these state boards whose investigatio ns revealed the cause or fault to be other than the mill. Many of the smaller mills not having an adequate technical organization, have placed themselves in the hands of the state employees, as they have found that they will always get a fair deal by doing so. Nevertheless, remember that the jobs of these state employees, and the appropriation of these state boards depend to a large extent on the number of abatement installations for which they are responsible.

2. The second defense we can put up is to step up our publicity and educate the public about the truth of the problem and what is being done. Remind the public that civilization, industry, and congregation of people in one place inevitably bring with them a certain degree of pollution. Above all, keep the case on a factual basis. It's easy to get emotional but it doesn't help anyone.

We can cool off the heat of the holy war only by a recognition that all pollution is not willful, and that some pollution is inevitable, and, at the same time, informing the public of the abatement measures being adopted at present. Our legislatures are responsive to public opinion and our boards and committees all are financed by the legislature. Again the National Council is doing an excellent job of publicity and the Wisconsin group is telling rather effectively what it is doing about the problem.

To review briefly those items which I would try to sell you to promote your own interests with respect to stream pollution problems, I suggest:

1. Continuing to adopt all known and proved pollution abatement methods, supporting your national council and other research agencies in developing new methods. As you will remember, this recommendation is hedged for certain local conditions.

2. Make your own stream survey, especially before building a new mill.

3. Tell the public what you're doing.

4. Do your best to keep peace among agencies when you are subject to more than one control agency or commission.

5. Promote having an industry member on the top control board. If you ever get a chance to do this, take advantage of the opportunity by all means. The way to do it, of course, is to have your management contact your representative in the legislature at some time when a revision of the law is under consideration.

6. Include local people on your stream survey and investigation. This is one I forgot to mention. If you are interested in a mill in another region or country, employ local scientists. They are more familiar with local water conditions, and local attitudes than you are.

7. Do everything you can to stop the use of the expression "population equivalent" in pollution work. I forgot to mention this one. In sanitary sewage work, they figure a pollution load of about 0.13 lb. B.O.D. per person per day. A sulphite mill has a waste liquor with a B.O.D. of approximately 500 lb. B.O.D. per ton of pulp, ordinarily 4000 times as much B.O.D. from a ton of pulp as from the sewage of one person.

By this reasoning, a 100-ton sulphite pulp mill is the equivalent in B.O.D. to a city of 400,000 population. It is a great temptation for a technician reporting on a river survey in behalf of a control board, to report the pollution load from an industry in terms of population equivalent. It is always spectacular to testify that the pulp mill has a population equivalent of 400,000 when everybody knows that the village in which the pulp mill is located has a population of only 4000 people. The correct statement should be that the pulp mill had a B.O.D. of 50,000 lb. per day whereas the village had a B.O.D. of 500 lb. per day.

It is a great temptation to be spectacular because in a trial or hearing, it is the spectacular testimony that gets into the afternoon papers, usually with the name of the individual who gave the spectacular report. Of course, such testimony is misleading, and all those hearing or reading the testimony, except the few who know the technical meaning of the test, misinterpret it.

It is a comparison of B.O.D. only. You and I know we would rather swim in or drink from the effluent of a 100-ton sulphite mill than from the effluent of a village of only a few people even though the so-called population equivalent of the pulp mill is 1000 times greater than that of the village. The discharge from the pulp mill is sterile and contains no bacteria or disease germs and is consequently noninjurious to public health. It is oxygen-consuming to a large extent, but oxygen-consuming only. Municipal sewage discharge is a definite hazard to public health as you know. In Wisconsin, the committee on water pollution through its employees has agreed with us that the term is misleading to the general public, and fair-minded as the committee has always been, it has agreed to discontinue the use of the term.

I notice in the report of the International Joint Committee

on Pollution of Boundary Waters, Survey of 1948–49, the statement is made that the population equivalent "does not necessarily imply equivalent bacterial pollution load." I don't know why the word "necessarily" was used. It just doesn't imply any equivalency by any stretch of the imagination. Anyway, the fact that there is a statement watered down and surrounded by hedges is an indication that the author of the report had some little twinge of conscience. The seventh point that I am trying to make then, is that you should do your part to get general agreement across the country to discontinue the use of the phrase "population equivalent" in industrial pollution work.

Kalamazoo Valley

The Kalamazoo Valley Section met at the Hotel Harris, Kalamazoo, Mich., on Nov. 6, 1952. About 60 individuals were present. A. T. Luey of the Sutherland Paper Co., Kalamazoo, presided as chairman. Knude Somme, chairman of the Swedish Association of Pulp and Paper Engineers, was present as a guest of R. T. Trelfa.

The address of the evening was given by W. R. Willets, of the Titanium Pigment Corp., New York, N. Y., on "Some Notes on Opacity." Mr. Willets' talk follows:

Some Notes on Opacity

William R. Willets and Louis E. Georgevits

Opacity is defined by Webster's Dictionary as the "quality or state of a body which renders it impervious to rays of light." A perfectly opaque body would not permit any light to pass through it. Conversely a perfectly transparent body would be one which would transmit without scattering all of the light falling on it; none would be reflected, refracted, nor absorbed. A translucent body falls between these two extremes with a portion of the light falling on it being transmitted, part absorbed, and part reflected and refracted:

In general, paper is a translucent material with varying degrees of opacity. As an example of the one extreme of complete opacity are the wrappings for packaging light-sensitive films whose prime purpose is to exclude all light and to permit none to reach the contents. The other extreme of complete transmission is approached by unfilled glassines and tracing papers. In between falls the great galaxy of most papers used for writing, printing, and packaging.

The above generalization might lead to the wholly erroneous conclusion that the consideration of the opacity of paper (or any other material) is a simple proposition, but nothing could be farther from the truth. Originally, it embraced only the science of physics but more recently the concept has been enlarged and expanded to embrace psychophysics. The theory and mathematics are complex but these notes will try to avoid both and be a simple discussion of what happens under certain conditions without any attempt to explain the phenomena on a theoretical or mathematical basis. For the theory and mathematics involved in a consideration of opacity reference should be made to the outstanding work of many investigators in this field among whom may be mentioned Judd, Davis, Hunter, Steele, Van den Akker, Harrison, Loughlin, and Maas.

In discussing opacity it should be remembered that there are two major ways of measuring the property, one by transmitted light and one by reflected light. The former would be important to a shade cloth manufacturer who wants his product to be so opaque to transmitted light that the outline of a figure in a lighted room would not be visible to a peeping Tom in the dark outside the window. The transmittance method would also have direct application to testing papers such as the opaque wrappers used for packaging photographic film where the complete exclusion of light is a required property. Actually the opacity of paper is generally judged by looking at the paper in reflected light with the paper backed by printing on the reverse side of the sheet itself, by a surface covered with light and dark areas, or frequently by both. Measurement of opacity by reflected light is the standard procedure. The ratio of light reflected from the surface of a sheet when backed by a black body (i.e., reflectance) to that reflected when backed by a white body is called contrast ratio. (With papers of relatively the same composition having approximately similar brightness and color there generally is a direct correlation between contrast ratio and opacity as measured by transmitted light:) The ratio of the light reflected by a sheet backed up by a black body to the reflectance of a pad of the same paper so thick as to be completely opaque (i.e., reflectivity) is known as printing opacity. Definite specifications for the light source, the brightness of the white and black bodies, and for the optical arrangement govern the standard methods for measuring "TAPPI opacity" (contrast ratio) and "printing opacity." As will be seen in some of the following results, the reflectivity with the green filter using the Hunter multipurpose reflectometer corresponds closely to the reflectivity as determined with the Bausch and Lomb opacimeter. (The reflectivity with the blue filter closely approximates "TAPPI brightness.") Contrast ratio and printing opacity determined using the green filter on the Hunter instrument correspond closely to the results obtained with the Bausch and Lomb opacimeter. (Since experimental error was unavoidable in making the many readings on which the tabulated results are based, failure in all cases to agree exactly with the theory and mathematics, is not strange.)

Fundamental mathematical concepts of opacity are em-

William R. Willets and Louis E. Georgevits, Technical Service Laboratories, Titanium Pigment Corp., a subsidiary of National Lead Co., New York, N. Y.

Table I. Effect of Calendering on Uncoated Paper

	Water-leaf, 57 lb., 25 × 40—500	*M.F. offset, 55 lb., 25 × 40—500*		
		No filler	*8% TiO_2*	*7% Clay*
Uncalendered				
Caliper, mils	6.2	4.0	4.0	4.0
Specific volume	1.97	1.31	1.31	1.31
Apparent density	0.57	0.76	0.76	0.76
Reflectivity, % (B & L)	88.5	87	90	87.5
Contrast ratio, %	87.5	80	88	83
Printing opacity, %	88	82	90	85
TAPPI brightness, %	...	77	84	77
Calendered				
Caliper, mils	3.3	3.2	3.1	3.1
Specific volume	1.04	1.05	1.02	1.02
Apparent density	0.96	0.95	0.98	0.98
Reflectivity, % (B & L)	86	86	89	85.5
Contrast ratio, %	84.3	79.5	87.5	82.5
Printing opacity, %	86	80	88.5	83

Table II. Effect of Calendering on Paper Coated on One Side

9 Lb., 25 × 40—500 Applied to 41 Lb. Raw Stock

	Raw stock	*Coated*	
		All clay	*80 Clay 20 Ti-Ca*
Uncalendered			
Caliper, mils	3.5	3.8	3.8
Specific volume	1.54	1.37	1.37
Apparent density	0.65	0.73	0.73
75° Gloss, % (approx.)	5.0	2.5	2.5
Reflectivity, % (B & L)	81	83.5	84.5
Contrast ratio, %	87.3	92.8	93.7
Printing opacity, %	90.8	94.2	95.0
TAPPI brightness, %	68.5	73.3	74.9
Calendered			
Caliper, mils	2.6	2.9	2.9
Specific volume	1.15	1.14	1.14
Apparent density	0.86	0.87	0.87
75° Gloss, % (approx.)	14	30	30
Reflectivity, % (B & L)	79.5	82	83
Contrast ratio, %	86.6	91.3	92.8
Printing opacity, %	89	92.5	93.5
TAPPI brightness, %	67.2	71.6	73.2

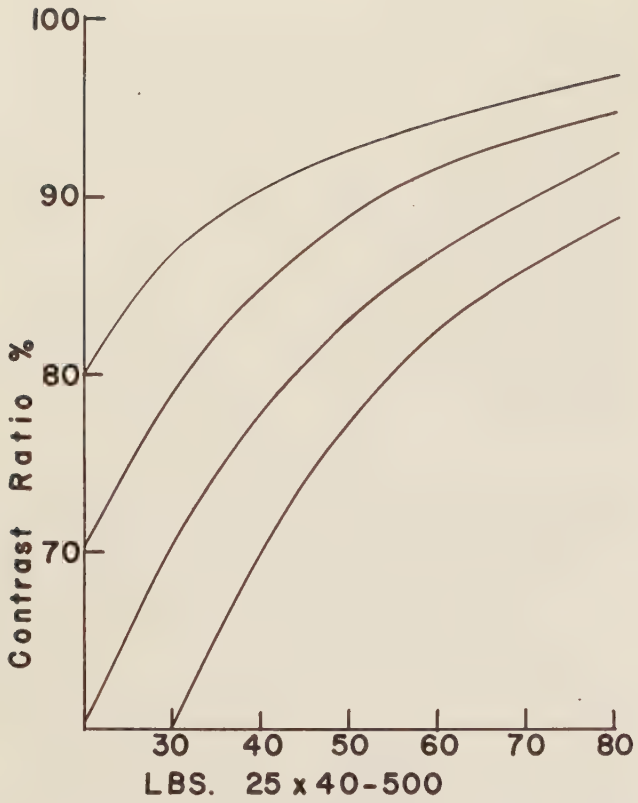


Fig. 1. Effect of basis weight on opacity of uncoated paper (from Kubelka-Munk curves)

braced in the Kubelka and Munk theory which has formed the basis of much of the literature on paper opacity. The theory is based on the definition of two fundamental optical constants: the specific scattering coefficient and the specific absorption coefficient. Curves derived from the Kubelka and Munk theory have a decided practical application and comprise TAPPI Data Sheet No. 65. These derived curves show the dependence of reflectance, contrast ratio, and printing opacity on thickness (and therefore all other factors being constant on basis weight), the relationship between printing opacity and contrast ratio and the relation between opacity and reflectivity.

For example, if the opacity of a sheet of paper at a given basis weight is known the opacity at any other given weight can be predicted providing all other factors are maintained constant. Examples derived from the Kubelka and Munk curves are shown in Fig. 1. The variation in contrast ratio is greater at the lower basis weights and opacities. In such lower ranges a pound variation in basis weight would cause about a point difference in opacity, at the higher ranges a pound variation would have little practical effect on contrast ratio. Such theoretical curves have been proved experimentally and actual relationships between contrast ratio and printing opacity on the one hand and basis weight on the other have been published.

Similarly if the opacity of a sheet of paper at a given reflectivity (brightness) is known its opacity at any other reflectivity can be predicted, all other factors being constant. Examples of such relationships again derived from the Kubelka and Munk curves are shown in Fig. 2. The effect on printing opacity is greater than on contrast ratio with both effects being less at the higher ranges of opacity. Ample experimental data substantiating the theory have been published.

The practical application of the Kubelka and Munk curves has already been mentioned. If a sheet of paper at 60-lb. basis (25 × 40—500) has a contrast ratio of 90% and a printing opacity of 92.5% at 80% reflectivity and the same sheet is required in a 50-lb. weight it is easy to see that the contrast ratio and printing opacity would be lowered by 3 to 4 points. To bring the lightweight sheet back to the original contrast ratio of the heavier sheet would require lowering its reflectivity by about 10 points but to bring it back to the original printing opacity would require less decrease in reflectivity. This example illustrates a point that has frequently been experienced in practice—that two papers can have identical printing opacities and widely different contrast ratios. It is true that in most cases there is a direct relationship between the two because in general only papers of rather similar reflectivities are compared on the basis of opacity. Generally, increasing opacity by lowering reflectivity by the use of a dulling dye or pigment would change the over-all appearance and character of the paper—a psychophysical factor which frequently might be undesirable. Actually in a case such as this, where equivalent opacity is desired in a lighter weight sheet comparable with that of a similar heavier weight sheet, the use of a suitable filler could be resorted to. If the ash content of the sheet in question were critical the use of an opaque pigment such as titanium dioxide (2 to 3% content) would make the 50-lb. sheet as opaque as the 60-lb. unpigmented sheet and at the

Table III. Effect of Color on Contrast Ratio of Uncoated Paper

Opaque Bonds, 12 Lb. 17 × 22—500

Paper color	Contrast ratio, % — Bausch & Lomb opacimeter	Hunter multipurpose reflectometer — Blue filter	Green filter	Amber filter
White	79.5	84.4	80.0	79.5
Blue	90.8	88.1	91.0	93.7
Green	89.1	92.9	89.3	92.7
Light yellow	73.3	89.5	74.4	72.5
Dark yellow	78.4	97.1	81.6	79.1
Pink	80.8	90.2	82.7	77.9

All made with 3% titanium dioxide except light yellow which was made with 4%.
White body reflectance for Hunter: Blue filter, 84.4%; Green filter, 86.2%; Amber filter, 86.2%.

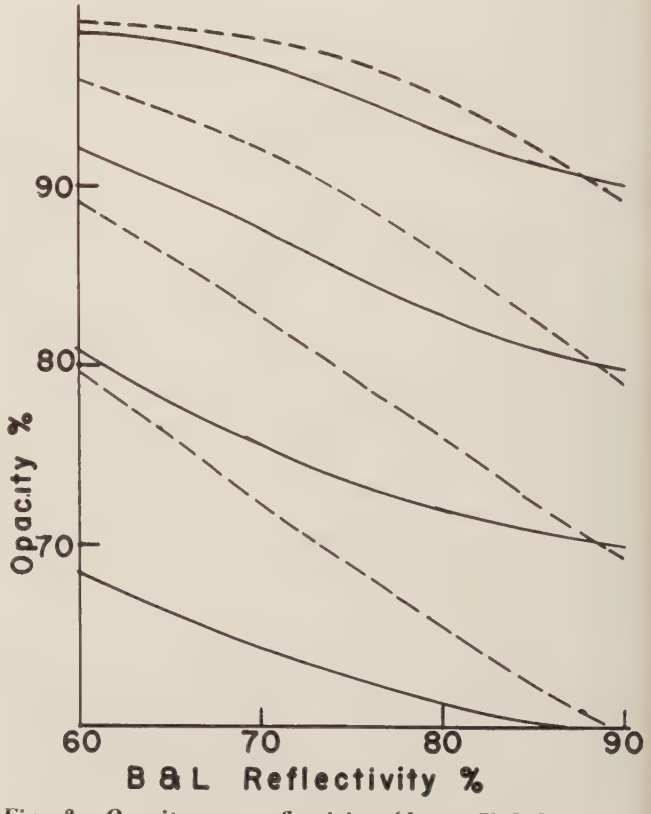


Fig. 2. Opacity vs. reflectivity (from Kubelka-Munk curves)

—— Contrast ratio R_0/R_{89}. ---- Printing opacity R_0/R_∞.

same time increase the reflectivity. If the reflectivity were then reduced to the original figure, the opacity would be still further increased.

The Kubelka and Munk theory holds very well for homogeneous papers. However, in using the curves based on it, the expression "all other factors being constant" should be kept well in mind.

For example, opacity is not directly dependent on basis weight unless the bulk of the paper is constant. This can easily be shown by decreasing the bulk (i.e., increasing the apparent density) of paper by calendering and measuring the various optical characteristics of the uncalendered and calendered sheets. For example, when the caliper and bulk of a waterleaf were greatly changed by calendering the decrease in constant ratio ("TAPPI opacity") was in the order of 3% and in printing opacity 2%. When the bulk of M.F. offset paper was similarly decreased the loss in opacity was much less. The same held true for coated paper, marked reductions in bulk produced by calendering (with greatly increased gloss) only lowered opacity by a point or two. (Details for the uncoated paper are given in Table I and for coated paper in Table II.)

These simple experiments show that calendering has relatively little effect on either reflectivity or opacity and that its major effect is the reduction of bulk and increase in gloss. It might be thought that the calendering which reduced bulk and increased density so appreciably should have had a greater effect in decreasing opacity because of the results obtained when density is increased by beating or wet pressing. Beating or wet pressing increases the fiber bonds and such bonds determine the area in which optical contact between fibers exists. Only the unbonded areas are responsible for light scattering since this only occurs at fiber-air interfaces. Evidently although calendering decreases bulk and increases density it has less effect on decreasing the actual area of fiber-air interfaces by increasing the areas in which optical contact between fibers occurs. The over-all effect of calendering on appearance is a psychophysical one—it makes the paper appear shiny. Any loss in opacity resulting from the decrease in thickness is at least in part compensated for by the corresponding decrease in reflectivity since, as has been noted, opacity increases with decreasing reflectivity—again all other factors being constant.

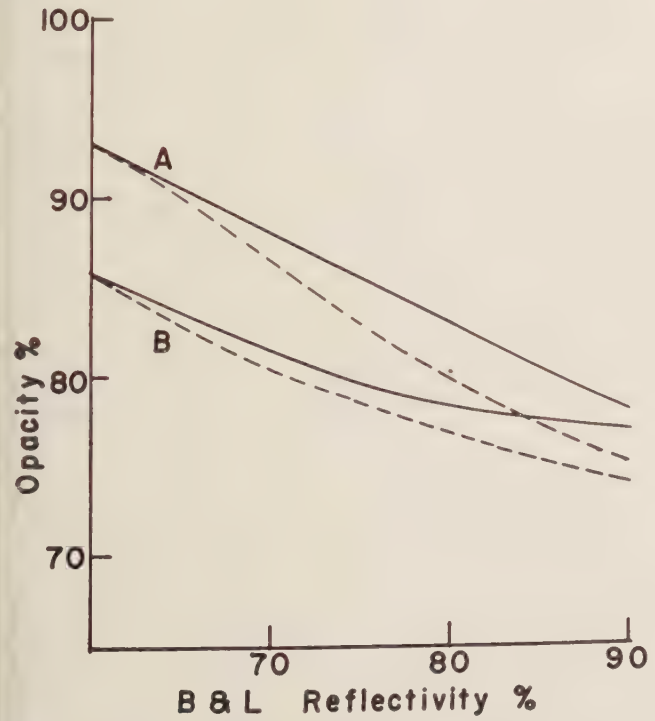


Fig. 3. Effect of brightness on opacity of paper coated on one side

A, printing opacity. B, contrast ratio. —— CIS—5 lb./ream. ----- Uncoated (from Kubelka-Munk curves).

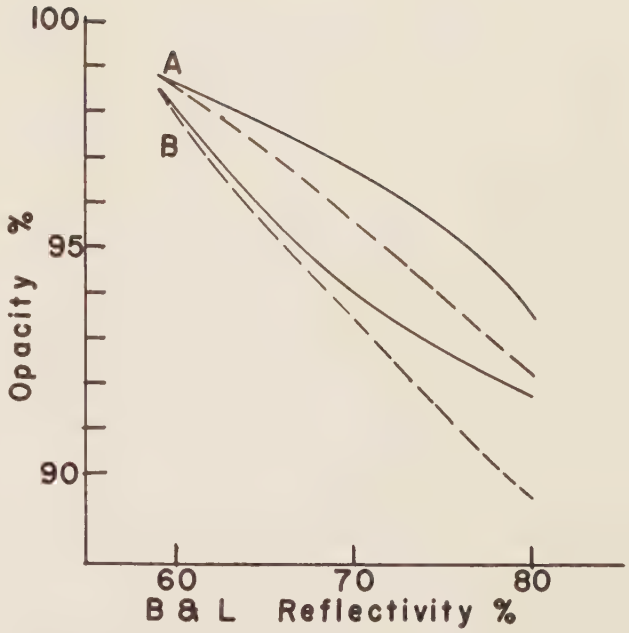


Fig. 4. Effect of brightness on opacity of paper coated both sides

A, printing opacity. B, contrast ratio. —— C2S-15 lb./ream. ----- Uncoated (from Kubelka-Munk curves).

It has also been noted that decreased reflectivity results in increased opacity. This holds true for coated paper as well as for uncoated paper but in the former case the effect of reflectivity is much less providing it is controlled only by the reflectivity of the coating itself and not of the raw stock. This is shown in Fig. 3 for paper coated on one side with the same coating dulled by the addition of a black pigment paste and in Fig. 4 for another raw stock coated on both sides with a different coating similarly dulled. The curves for the coated

Table IV. Effect of Tinting Coating on Opacity of Paper Coated on One Side

Coated 4 Lb., 25 × 40—500 on 25 Lb. Raw Stock

	Color of coating			
	No tint	*Gray*	*Blue*	*Orange*
Reflectivity, R_∞, %				
Bausch and Lomb	87.2	77.8	73.0	89.0
Hunter				
Blue filter	81.7	77.2	81.8	79.4
Green filter	88.1	77.8	73.6	88.4
Amber filter	89.7	77.7	69.0	92.1
Comp. yellow	9.1	0.8	−17.4	14.4
Reflectance, R_o, %				
Bausch and Lomb	65.5	64.5	61.0	69.0
Hunter				
Blue filter	68.1	67.6	69.3	68.5
Green filter	66.5	65.0	62.1	67.5
Amber filter	65.2	64.4	59.6	67.5
Printing opacity, R_o/R_∞, %				
Bausch and Lomb	75.1	82.9	83.6	77.5
Hunter				
Blue filter	83.4	87.6	84.7	79.4
Green filter	75.7	83.5	84.4	76.4
Amber filter	72.6	82.9	86.4	73.3
Contrast ratio (Bausch and Lomb), %	73.5	77.6	79.0	76.7
Ultimate % reflectance (Hunter) of coatings applied				
Blue filter	91	74	82.5	80
Green filter	92	73.5	70.5	89
Amber filter	93	72.5	65.0	93.0
Comp. yellow	2.2	−2.0	−23.8	14.6

Table V. Effect of Brightness of Coating on Opacity of Paper Coated on Both Sides

Coated 7.5 Lb. per Side, 25 × 40—500 on 41 Lb. Raw Stock

	10% TiO_2–90% clay			All clay		
	Un-tinted	Tinted Light	Tinted Dark	Un-tinted	Tinted Light	Tinted Dark
Hunter reflectivity, R_∞, %						
Blue filter	76.0	74.8	58.3	74.5	67.4	60.8
Green filter	78.2	76.8	59.8	76.0	70.0	63.5
Amber filter	78.3	77.7	60.2	77.0	70.7	63.9
Comp. yellow	2.7	3.5	3.2	3.3	4.7	4.9
Bausch and Lomb, %						
Reflectivity, R_∞	80.0	77.0	60.0	75.9	70.4	63.3
Reflectance, R_o	74.5	73.3	59.1	70.4	67.3	60.6
Printing opacity, R_n/R_∞	93.1	95.3	98.6	93.3	95.5	96.0
Contrast ratio, R_o R_∞	92.5	93.0	97.5	90.1	92.0	93.8

paper are derived from actual experimental data while those for the uncoated are derived from the Kubelka and Munk curves of TAPPI Data Sheet No. 65. It is logical that dulling only the coating would have less effect in increasing opacity than dulling the entire sheet throughout since only the opacity of the coating itself is increased. It has been stated that lowering the brightness of an uncoated sheet by adding a dull dye is not a particularly good method of increasing its opacity and the same holds even more true for using a dull coating. To produce any appreciable change in opacity the coating would have to be dulled to such an extent that the appearance and character of the sheet would be changed. Actually it might be more advisable to dull the raw stock to increase its opacity and then apply a highly opaque, bright and white coating to cover it.

Also, the part played by color in opacity is not always recognized although for years the paint industry has realized that a yellow-tinted paint has less covering power than one tinted blue, all other things being equal, and results showing the effect of dyestuffs on paper opacity have also been published. Such an effect of color on opacity was shown by measuring the contrast ratio of a series of lightweight tinted bond papers. A yellow-tinted sheet had 6 points lower contrast ratio (measured on the Bausch and Lomb opacimeter) than a white paper, about 7 to 8 points lower than a pink-tinted sheet, and over 15 points lower than blue or green-tinted sheets. In all these cases the fiber furnish was similar, and the pigmentation the same with the exception that the titanium dioxide had been increased in the light yellow sheet in an attempt to increase its opacity. However, when contrast ratio was measured using the blue filter on the Hunter reflectometer the light-yellow paper gave a reading 5 points higher than the white, about equivalent to the blue and pink but lower than the green. The high contrast ratio of the light yellow sheet when determined in blue light and its low contrast ratio in green and amber light can be explained by the fact that the light yellow paper absorbed much of the blue light and thus did not permit it to be transmitted through the sheet and reflected back by the white body. Less of the green and amber light was thus absorbed and therefore could be transmitted through the sheet and in one case absorbed by the black body and in the other reflected back through the sheet by the white body. Generally speaking the maximum opacifying effect of a dyestuff is obtained when the light used to measure the opacity has a wavelength corresponding to the maximum absorption for the dyestuff. The color of the paper and the color of the light used for viewing both have a decided effect on apparent visual opacity. (Details are given in Table III.)

This is true for coated papers also, as shown by the results obtained with untinted and tinted coatings. Varying the color of the coated paper by tinting the coating affects opacity but the effect is not entirely analogous to that resulting from dying uncoated paper. For example, paper coated on one side with an untinted coating had a contrast ratio (Bausch and Lomb) of 73.5%, a strong blue tint in the coating increased this to 79%, while a strong orange tint only increased it to 76.7%. The difference in printing opacity (Bausch and Lomb) was more pronounced—75.1% for the untinted, 83.6% for the blue, and 77.5% for the orange. Printing opacity determined using the Hunter multipurpose reflectometer was higher for the blue tinted than for the orange tinted when using blue, green, or amber light. (Details are given in Table IV.) The effect of dulling coatings applied to both sides of a sheet without materially affecting the neutrality of the final color was to increase opacity, as noted previously. (Details are in given in Table V.)

Up to this point only the opacity of unprinted sheets had been considered. When paper is printed the problem of just how pronounced the printing will appear on the reverse side of the sheet is far more complex than the determination of "TAPPI opacity" or "printing opacity." "Show-through," that is, the appearance of a printed character on the reverse side of the printing, is of paramount practical importance and while somewhat dependent on opacity (either contrast ratio or printing opacity) involves other factors. Actually show-through under any circumstances is at least the result of a dual effect, even assuming constant ink penetration. When a sheet of paper is backed up with another similar sheet bearing a printed character the effect is the same as measured in determining printing opacity. When the sheet is itself printed and viewed from the reverse side there is an added effect because of the penetration of the printing ink vehicle which renders more transparent that portion of the paper beneath the printed character. To this dual effect must also be added such factors as the color of the paper and the light used for viewing (as has already been pointed out in contrast ratio and printing opacity measurements) and also the color of the printed character. The whole proposition thus becomes increasingly more complex as the possible factors involved increase.

Such complexity can be shown by determining the show-through of printed samples. The ratio of the reflectance on the reverse of printing to the reflectivity of the paper itself ("printing brightness ratio") gives a numerical expression of such show-through. This was determined using both the Bausch and Lomb opacimeter and the Hunter multi-purpose

Table VI. Relation Between Optical Properties and "Show-Through"

	Uncoated filled 15% Clay	Uncoated filled 5% TiO_2	Coated both sides 11 Lb. per ream All clay	Coated both sides 11 Lb. per ream 10% TiO_2
Bausch and Lomb, %				
Contrast ratio	91.5	94.0	90.7	92.4
Printing opacity	92.0	94.0	93.0	94.0
Reflectivity				
Reverse unprinted area, R_∞	86.3	88.5	82.0	83.5
Reverse printed area, R_p	70.0	75.5	73.8	76.5
Ratio, R_p/R_∞	81.1	85.3	90.0	91.6
Hunter reflectivity, %				
Reverse unprinted area, R_∞				
Blue filter	78.7	81.6	70.5	73.5
Green filter	86.4	88.5	82.0	83.7
Amber filter	87.3	89.5	85.2	86.3
Comparative yellowness	10.0	8.9	17.9	15.3
Reverse printed area, R_p				
Blue filter	67.8	73.0	67.5	71.0
Green filter	71.0	75.8	72.8	76.2
Amber filter	71.0	75.8	72.8	76.5
Ratio R_p/R_∞				
Blue filter	86.1	89.5	95.7	96.6
Green filter	82.2	85.6	88.8	91.0
Amber filter	81.3	84.7	85.4	88.6

Note: R_p/R_∞ = printing brightness ratio.

reflectometer with various filters. Samples of clay and titanium dioxide filled uncoated paper and of coated paper were printed with a solid black using a proof-press under carefully controlled conditions. In the case of the clay-filled sheet the "printing brightness ratio" was about 11 points lower than the printing opacity, in the case of the titanium dioxide filled sheet the difference less than 9 points, while for the coated paper the difference was 3 points or less. In all cases the "printing brightness ratio" as determined with the Hunter multipurpose reflectometer was lower when determined using green or amber light than when determined using blue light. (Details are given in Table VI.) As has been noted previously opacity (either contrast ratio or printing opacity) is also generally higher when determined using blue light than when using green or amber light.

The significant point to be noted here is that actual show-through was always worse than would be indicated by printing opacity results, as shown by the fact that the printing opacity was always higher than the "printing brightness ratio." The difference between the two figures was less for samples containing titanium dioxide than for corresponding unpigmented samples showing that the pigment retained its opacity in contact with the printing ink vehicle because of the differences in refractive index. The difference between the tests on uncoated and coated papers probably results from the lesser strike-through (i.e., penetration) of the printing ink vehicle for the coated paper.

The same indications were obtained in the case of lightweight offset paper. Here the samples were printed in solid black with black oil ink using a commercial sheet-fed offset press and with four-color, heat-set ink using a commercial web-fed offset press. In every case the show-through was worse, as shown by the printing brightness ratio, than would be anticipated from the printing opacity. The show-through was greater with the sheet-fed printing with oil ink than with the web-fed four-color heat-set ink printing. Actually this can be explained on two bases—one the lessened strike-through (i.e., penetration) when the heat-set ink was used and the other the color of the ink. (Details are given in Table VII.) As would be expected, paper containing 3% titanium dioxide had better initial brightness and opacity and less show-through than either an unfilled sheet or one containing 6.5% clay.

The above notes have attempted to point out at least some of the factors that have an effect on practical opacity but there are many others which are related and which have been treated at length in the literature.

For example, it is well known that some pulps are basically more opaque than others. Even within a single grade such as bleached sulphite considerable variation in the coefficients of scattering and absorption has been shown, and since opacity is a function of both it is easy to see why the final opacity of a sheet of paper is so greatly affected by the pulp used to make it. As already noted opacity is influenced by the fiber areas in optical contact with each other as controlled by fiber bonding, which in turn is related to the type of pulp, the degree of beating and wet pressing and also to some extent to calendering. An increase in the area in optical contact by fiber bonding and a resultant decrease in the area not in optical contact results in lower opacity because light scattering only occurs at fiber-air interfaces.

It is also known that all other factors being constant opacity increases with a decrease in brightness. However, the scattering and absorption coefficients vary, being dependent on the wavelength of light used for their determination and also on the color of the paper under test. Most of the theoretical considerations and experimental results appearing in the literature apply satisfactorily to a homogeneous sheet, one in which color and brightness and therefore specific scattering and absorption are constant throughout the entire thickness. In the case of coated paper the problem is far more complex because there are two or three or even more layers to take into consideration, each with its own constants of density, thickness, scattering, and absorption. Actually the effect of brightness on opacity, while greater at some opacity and brightness ranges than at others, does not hold too much practical importance since to raise opacity appreciably requires lowering the brightness to such an extent as to alter the over-all appearance and character of the sheet in question—generally if a white sheet is desired a dull gray or one with a distinct blue or other hue would not be satisfactory.

Table VII. "Show-Through" of Uncoated Offset Paper
42 Lb., 25 × 40—500

	Filler content in sheet		
	No filler	6.5% Clay	3% TiO_2
Hunter reflectivity, %			
Blue	77.5	78	83
Green	85.5	87	90
Amber	87.5	88	91
Bausch and Lomb			
% Contrast ratio	71.5	76	83
% Printing opacity	72.5	78	83.5
% Printing brightness ratio			
Sheet-fed offset (black oil ink)	62	64	74
Web-fed four-color offset (heat set ink)	67	73	78

While the generalization has been made that opacity decreases with increased brightness it should be noted that certain fillers and especially the opaque white pigments with their high refractive index result in an increase in both properties. If the original brightness is maintained by the use of suitable tinting colors the final opacity will, of course, be still higher. This point has a practical meaning where it is desired to increase the opacity of a sheet of paper without either lowering or raising its brightness.

Of course the whole question of opacity is made still more complex when the presence of fillers in the sheet is considered. In a sheet consisting of fiber only one interface plays a part, that between air and fiber. When fillers are used two more interfaces enter the consideration, fiber-filler and air-filler. Added to this are the basic scattering and absorption characteristics of the many types of fillers which are influenced by their particle size and shape, refractive index, brightness, and color.

From a practical point of view printing show-through is one of the paramount considerations in opacity. Unfortunately there is no direct correlation between the measured properties of contrast ratio and printing opacity and show-through, because these measured properties, although playing an important part, cannot take into account the penetration of the printing ink vehicle and the resultant transparentizing of the paper beneath the printing. Frequently two sheets may have the same opacity and ink penetration characteristics but widely different show-through even when printed under identical conditions, because of the way the original opacity was accomplished. If one contains a high refractive index pigment and the other a low refractive index pigment in greater amount, the show-through in the first case will be less even if the opacities are similar. Of course in any case the degree of penetration of the ink, the color of the ink, and the color of the light used for viewing all play important roles.

To summarize: the practical consideration of opacity involves properties some of which are definable, measurable, and even predictable but also embraces those whose effects are difficult to define, still more difficult to measure, and almost impossible to predict. Even though the theory and mathematics involved in a fundamental consideration of opacity may seem unduly complex luckily investigators in the field have simplified the proposition to the point of real practical significance. By combining the application of theory with operating know-how and a knowledge of end-use requirements, great help in solving opacity problems is bound to result.

Use of Electronic Gages to Determine the Fatigue Point in Corrugated Containers

C. S. MACNAIR

THIS entire series of tests was started to determine the cause of failure through some method that would show a step-by-step progression of a corrugated container while being subjected to force. It was felt that present testing methods, while they provided an end point at which visual failure could be determined, did not provide a means of studying, except through visual means, the actual history of the disintegration of a container.

Careful study has seemed to indicate that all containers may fail from the same cause. That cause is the inability of the board itself to withstand being forced into a compound curve (the curvature forming both across the grain of the paper and with the grain of the paper at the same time).

When it is considered that a piece of corrugated board

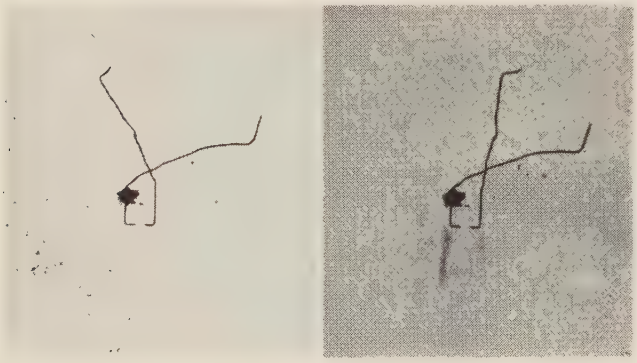


Fig. 1

X-ray plate at right shows an electronic gage mounted on a section of corrugated board cut from a box after a Conbur crush test had been made.

X-ray picture at left had too great an exposure time to attain the correct penetration through the board. It was taken from the opposite side. The cloudy effect is created when the density is increased by having the plies which make up a piece of corrugated board brought closer together than normal.

formed into a regular slotted container when subjected to stress and strains which distort the side walls can do nothing else, when distorted, but form itself into a compound curve because it is held rigidly on all four sides of the panel, this observation becomes self-evident. It seems surprising in the light of this self-evident observation that there is no standard test which takes this point into consideration.

While it is true that there are certain limits of elasticity in corrugated board which will allow a certain amount of springiness in the panels, after the limit of elasticity has been reached further distortion, measured in microinches per inch, will cause a marked failure even under ideal laboratory conditions.

Various other tests, not a part of this paper, have led us to believe that after the limits of elasticity have been reached in the formation of a compound curve, then an additional force causing a curvature of more than 400 microinches per inch will cause a definite fracture. These tests have been made under ideal laboratory conditions. It is believed, from these tests, that when this point has been reached the fatigue point of the board has been reached. This accounts for the fatigue point, established through known test procedures, varying with conditions of humidity, temperature, and time.

C. S. MACNAIR, Consultant in Product Development, Consumer Products, Acme Steel Co., Chicago, Ill.

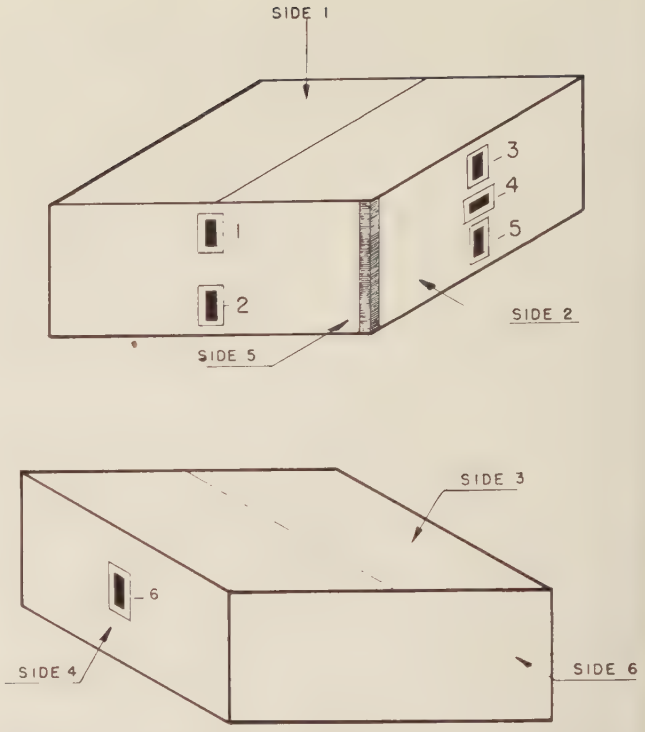


Fig. 2 Arrangement of electronic gages on a conjugated container

In devising a test to explore the merits of this observation, Baldwin-Southwick electronic gages were used and a Conbur testing unit was decided upon as the testing device which would give the most accurate answers. The electronic gages used in this test are a product of the Baldwin-Lima-Hamilton Co. They are instruments about the size of a large postage stamp and are made to be hooked up electronically to a Baldwin-Lima-Hamilton galvanic wheatstone bridge. The electronic gages are so made that they are very sensitive to curvature or distortion in the long direction of their measurement. They are not sensitive to distortion in the short dimension of their measurement. When compared with a similar electronic gage held rigidly in a fixed position, the differential between the curvature of the free gage and the reading of the fixed gage become a unit of measure. When the free gage is permitted to curve inwardly at the center of the arc as you look at the face of the gage, the measurements will be negative. When it is permitted to curve outward at the center as you look at the gage the measurements will be positive. Therefore, in reading these measurements it is necessary to start at the true center of the galvanometer. This center of the galvanometer is 1000. This gives a possible reading of from 1000 to zero on the negative side, and 1000 to 2000 on the positive side. There are other ranges on the scale giving much wider possible readings, but for the work for which we are using the electronic gages, this is sufficient for all practical purposes.

Each gage consists of a grid of very fine, almost microscopic, wires stretched on a piece of glassine paper between two points exactly an inch apart in the longitudinal direction, an elongation will produce the positive readings and a contraction will produce the negative readings. This grid is buried in a film of lacquer which, in itself, is very flexible. When the

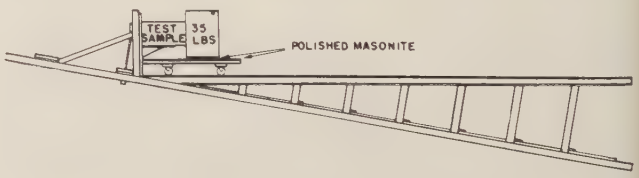


Fig. 3. Conbur crush test

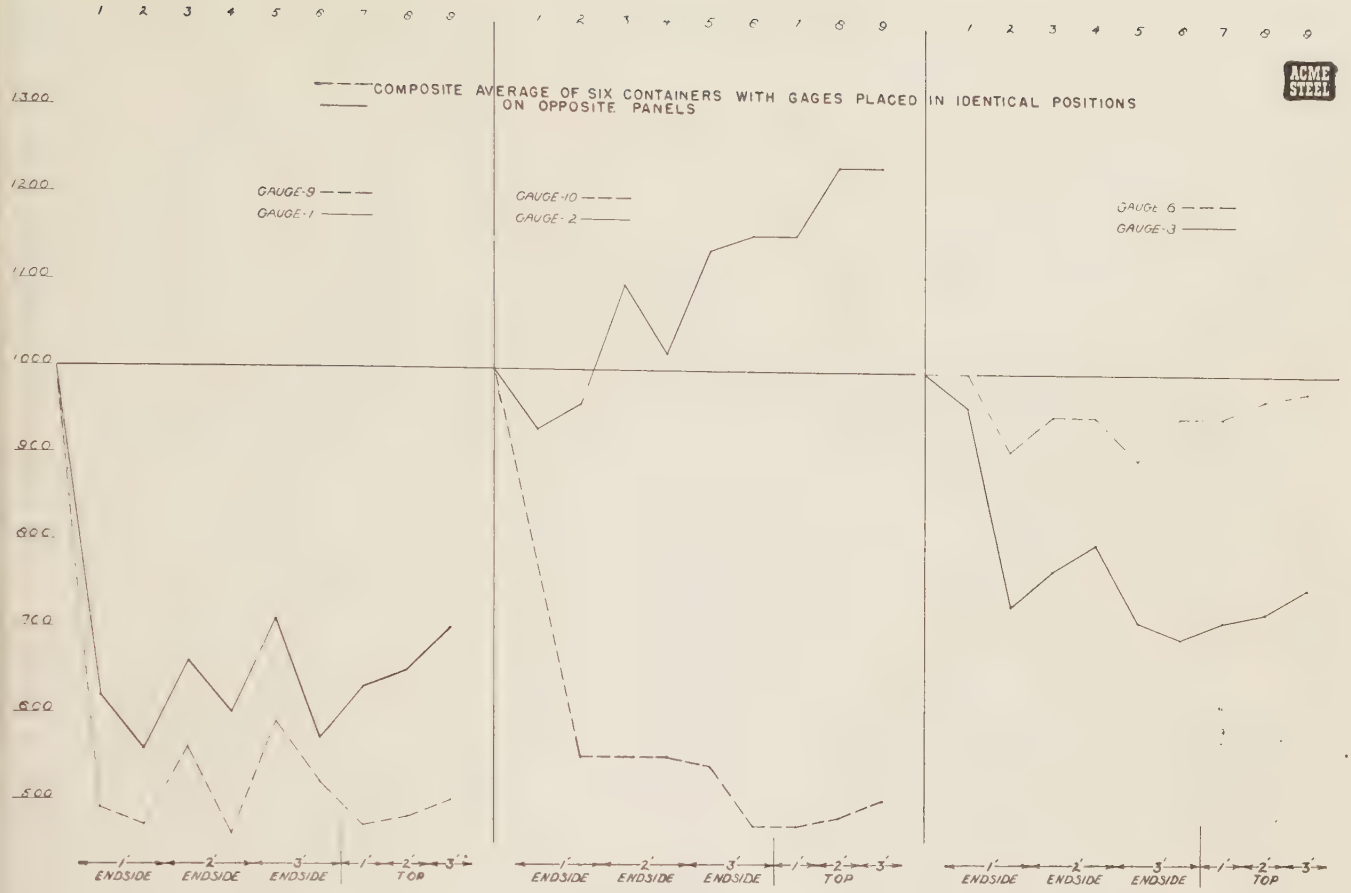

COMPOSITE AVERAGE OF SIX CONTAINERS WITH GAGES PLACED IN IDENTICAL POSITIONS ON OPPOSITE PANELS
ACME STEEL
GAUGE-9
GAUGE-1
GAUGE-10
GAUGE-2
GAUGE-6
GAUGE-3
1300
1200
1100
1000
900
800
700
600
500
1 2 3 4 5 6 7 8 9
1' 2' 3' 1' 2' 3'
ENDSIDE ENDSIDE ENDSIDE TOP

Fig. 4

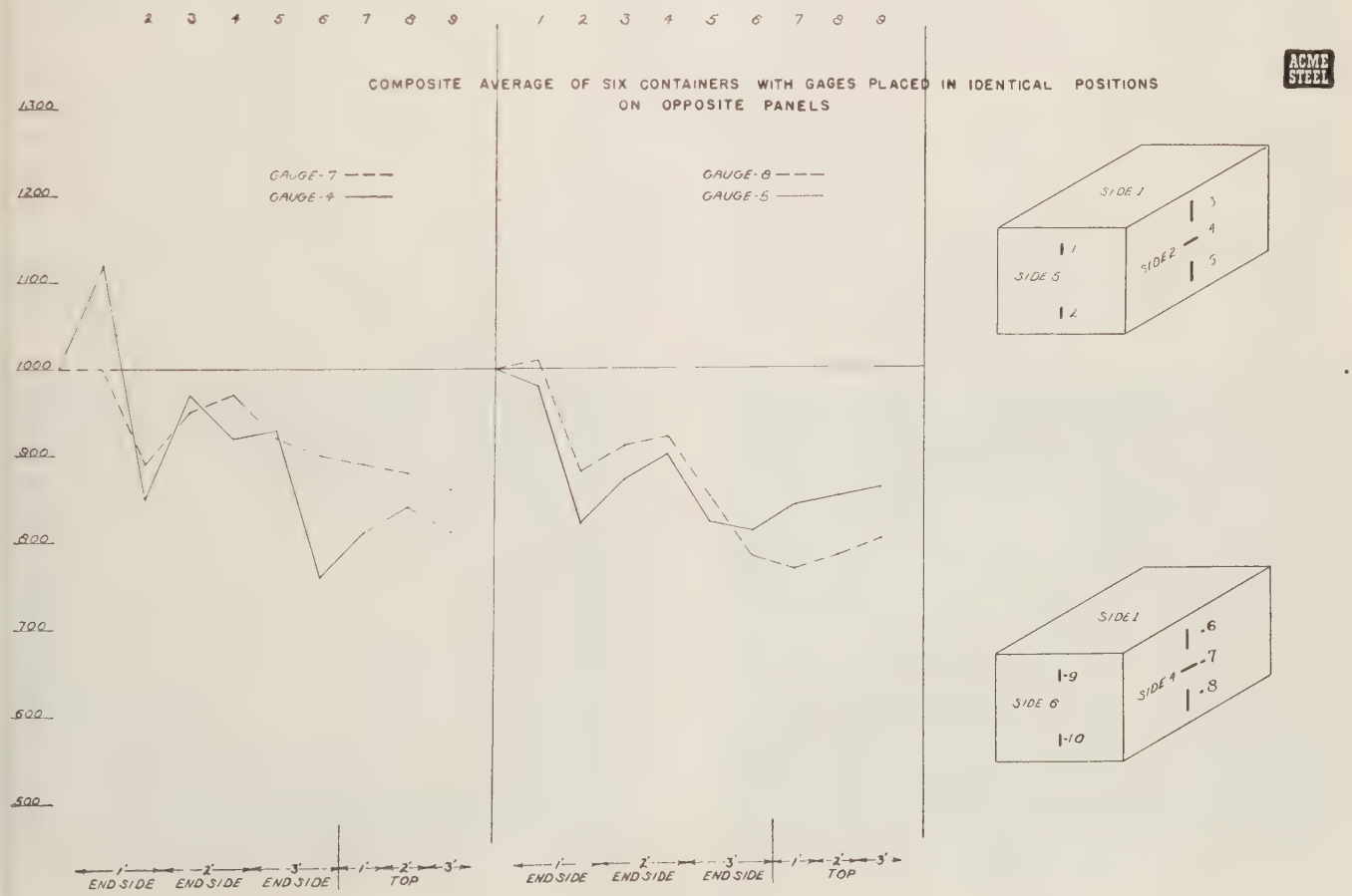

COMPOSITE AVERAGE OF SIX CONTAINERS WITH GAGES PLACED IN IDENTICAL POSITIONS ON OPPOSITE PANELS
ACME STEEL
GAUGE-7
GAUGE-4
GAUGE-8
GAUGE-5
1300
1200
1100
1000
900
800
700
600
500
2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9
1' 2' 3' 1' 2' 3'
ENDSIDE ENDSIDE ENDSIDE TOP
SIDE 1
SIDE 2
SIDE 5
1
2
3
4
5
SIDE 1
SIDE 4
SIDE 6
1-9
1-10
.6
.7
.8

Fig. 5

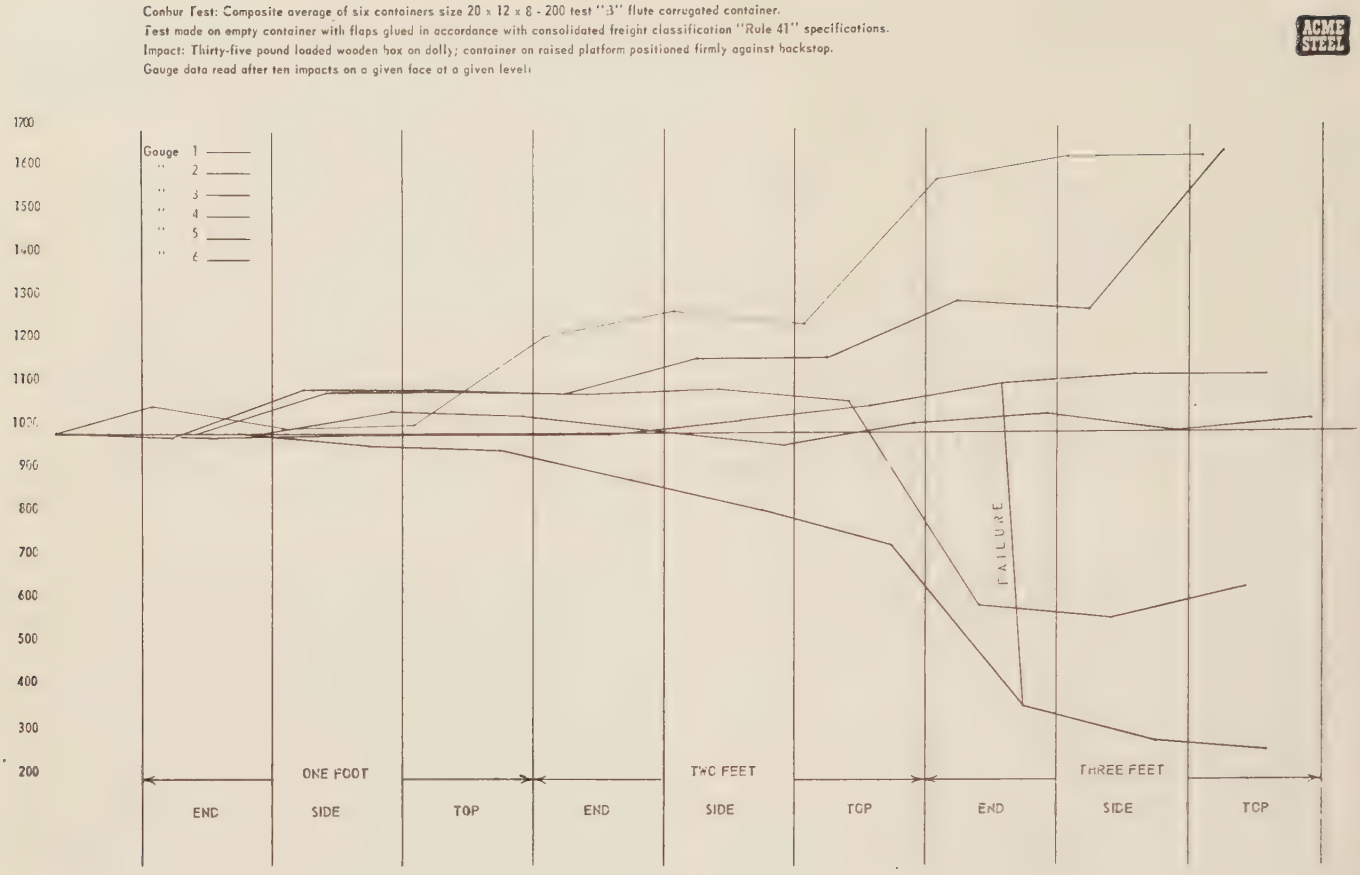


Fig. 6

gage is adhered to an object by means of a similar film of flexible lacquer, the curvature of the wire follows accurately the curvature of the surface to which the gage is adhered. In any event, the measurement is the measurement of the curvature of the gage, and the surface that it adheres to actuates the curvature.

In a test on corrugated board we are only interested in the curvature as it becomes permanent, and after a very narrow limit of elasticity the side wall of a corrugated container becomes progressively curved with a set curve as pressure is applied, whether that pressure be continuous or repetitive.

By putting gages (Fig. 1) in various positions on a corrugated container, the reactions under the load or shock can be very carefully analyzed. By trial and error we have arrived at the positions indicated on Fig. 2, and we have standardized on those. The greatest distortion usually occurs in the longest panel of a container, that is panels 2 and 4. The electronic gages on panel 2 will record distortion in four directions. Gages 3 and 5 record distortion from top to bottom, either inwardly or outwardly. Gage 4 records horizontal distortion inwardly and outwardly. Generally the panel will not disintegrate until the limit of its ability to form in a compound curve has been reached. Fracture in the board occurs for the same general reasons that apply when plate glass is fractured.

Generally speaking, a differential between no. 4 gage and any

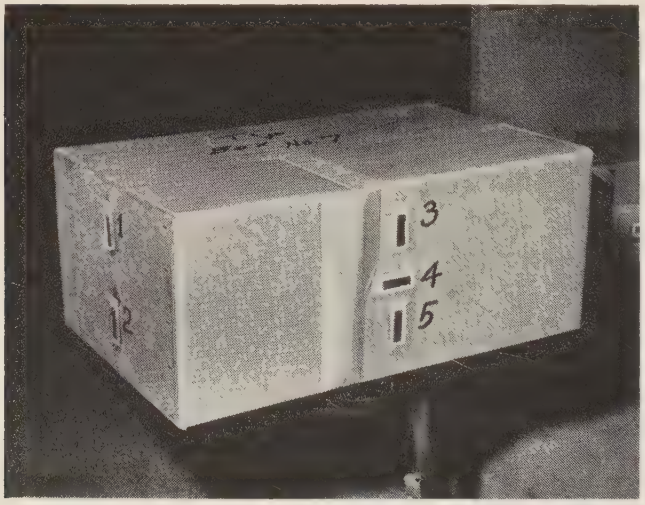


Fig. 7

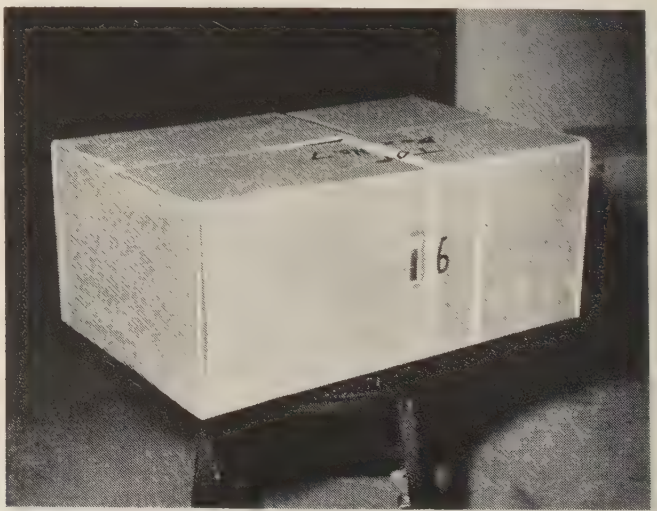


Fig. 8

Conbur Test composite average of six containers size 12 x 8 x 14 - 200 test "3" flute corrugated container.
Test made on empty container with flaps glued in accordance with consolidated freight classification "Rule 41" specifications
Impact: thirty-five pound loaded wooden box on dolly; container on raised platform positioned firmly against backstop.
Gauge data read after ten impacts on a given face at a given level.

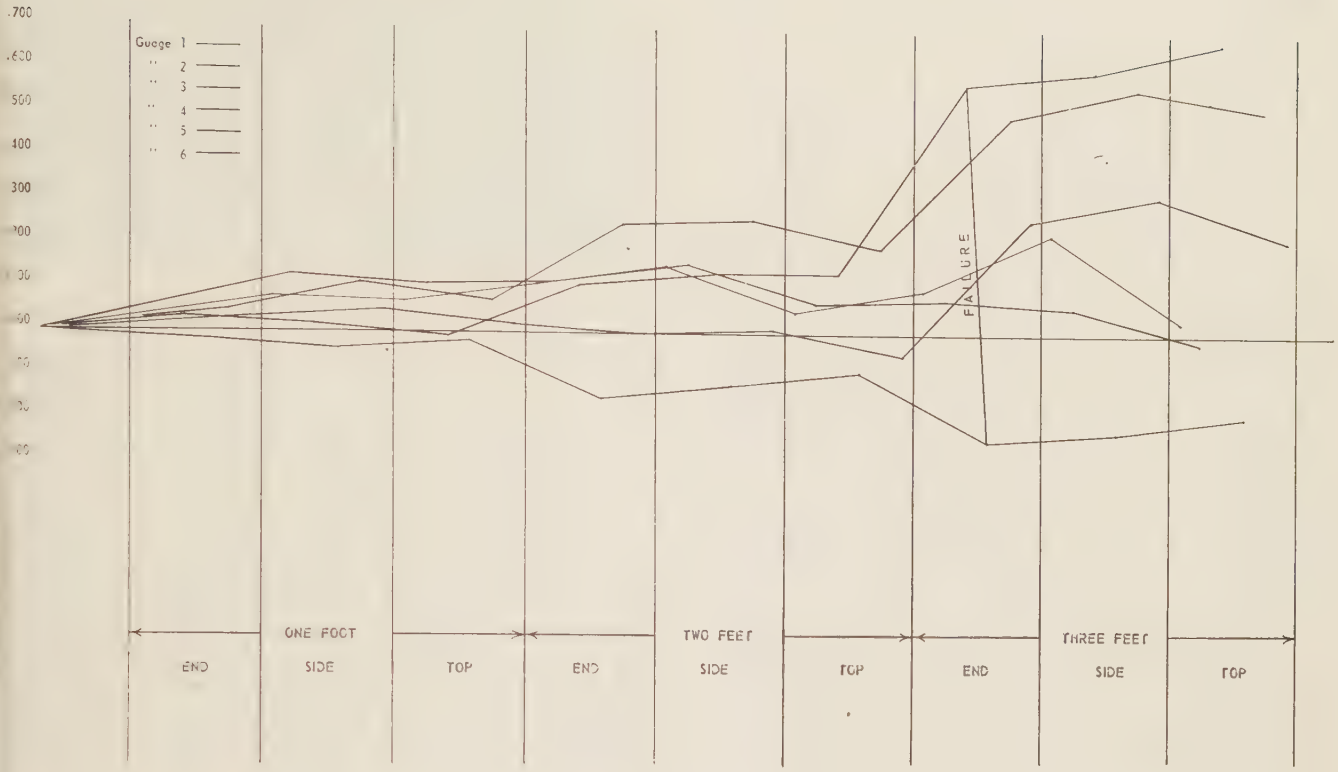


Fig. 9

of the other gages amounting to over 400 points (microinches per inch), will indicate fracture. When a single gage out records more than this, and the other gages tend to maintain their pattern it is generally due to faulty manufacture of the board itself or of the manufacturer's joint. If there is a wide divergence of most gages from an established pattern at any one point, definite failure is indicated. Failure does not become visual until a container has been subjected to as many as 30 or 40 additional impacts.

In devising a test using a Conbur unit certain modifications were necessary in order that the electronic gage could be used. It was necessary to have the container to be tested placed in one fixed position, therefore it was decided to use the variation of the Conbur test procedures developed by Paul Barkus in the laboratory of the Owens-Illinois Glass Co. Mr. Barkus has given this variation of the Conbur test procedures the name of "Conbur Crush Test."

In the Conbur crush test the sample to be tested is placed

Fig. 10

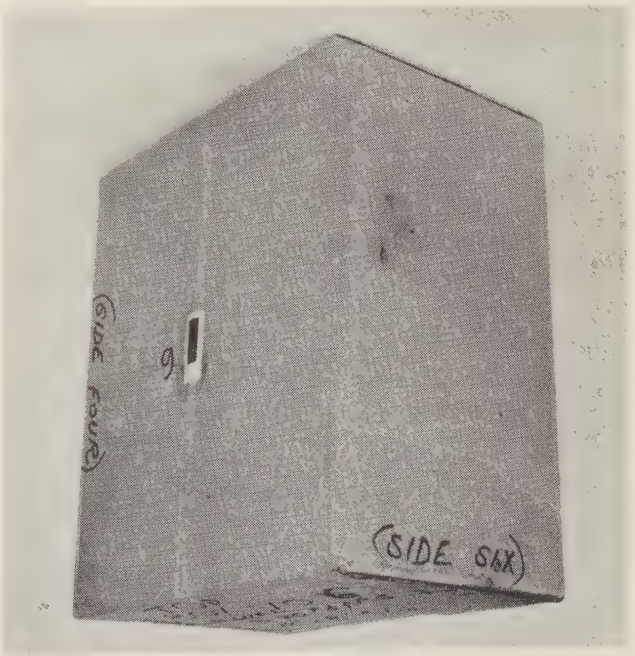


Fig. 11

on a shelf that has been built as a fixed part of the bumper. The dolly is free to pass under this shelf and contact the bumper in the customary manner. This test procedure is illustrated in Fig. 3. The container to be tested is empty since this is a test of the board structure when formed into a box. For the purpose of this test, the dolly was covered with polished masonite.

The impact was delivered by a wooden box constructed for this test, and loaded with sawdust packed to a density which provided a gross weight of exactly 35 lb. This wooden box was also faced with polished masonite. The purpose of the masonite is to reduce to as nearly zero as was practical the friction between the impact weight and the dolly.

The procedure for the Conbur crush test is as follows: before the test was started the impact load was placed in position on the dolly directly in contact with the manufacturer's joint end of the test sample. All gages were set at zero. The trip mechanism of the dolly release was set at 1 ft. After ten impacts at 1 ft. the signal of each electronic gage was measured for distortion. The test sample was then turned 90° so that the side with the manufacturer's joint was opposite the impact weight. After ten impacts at 1 ft. the signal of each gage was again measured.

The carton was then turned so that the top was opposite the impact weight and after ten impacts each electronic gage signal was measured. This cycle was repeated with the trip mechanism set for 2 ft. and again at 3 ft.

The width of the shelf was made variable so that additions could be made to the original width in such a manner that the shelf came to two thirds of the box length or width whichever the case may be during each impact.

Precaution was used to insure that the impact end of the test sample and the impact weight were "squared up" after each impact, so that at the time the dolly started its travel the impact weight and the tested end of the sample were parallel.

After the position of the electronic gages had been determined, extensive tests were conducted to determine whether there was a difference in behavior between gages placed as illustrated and gages placed in identical positions on opposite panels. Figures 4 and 5 tend to show that there is no significant difference between the action of any one gage used and its exact opposite. It was therefore decided that a very truthful story could be worked out with six gages.

Figures 6, 7, and 8 and 9, 10, and 11, which are typical of the results of numerous trials, show the history of this test. There are three columns on the graph for each cycle. As an example, the 1-ft. cycle has a column for the end, another for the side, and another for the top. Each column is subdivided into six separate columns.

It is to be noted that these graphs make no attempt to record shock within the limits of elasticity of the board itself. We are only interested, in this paper, in showing the distortion or permanent set that the container has taken at any one part of the cycle. A permanent set occurs at a point beyond the limit of elasticity.

Gage no. 4 furnishes the key to this test and the limit of the corrugated board to form itself into a compound curve is taken always in terms of the no. 4 gage in its relation to all other gages. A differential between gage no. 4 and any other gage of more than 400 microinches per inch seems to indicate fracture. After that point has been reached the failure is definite, even though it does not show up visually until many additional impacts have been made.

Some of the interesting points to consider is the fact that there is no all-over curvature of any one panel. Permanent set seems to take place on the side panel in two well-pronounced waves with the crests centering horizontally through gages 3 and 5, and the valley centering horizontally through gages 4 and 6, or the converse of this condition can develop.

There seems to be no relationship between the size of the container and its ability to fracture.

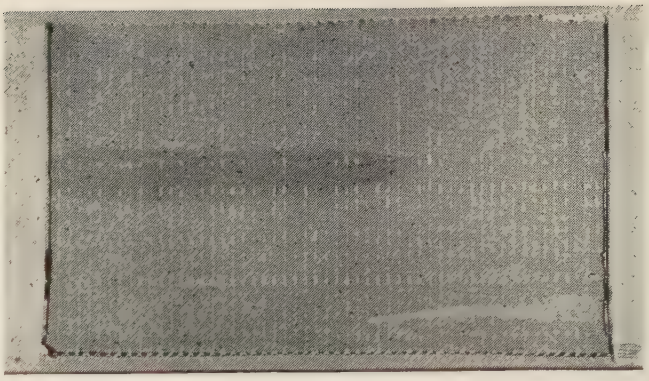


Fig. 12

The conclusion of this study seems to indicate that corrugated container board behaves in a manner similar to plate glass. It will bend either with the grain or across the grain a great distance before the limit of elasticity has been reached. When it has been forced into a compound curve, that is forced to a curvature in two directions at once, the limit of elasticiy is very low. A differential of 400 microinches per inch in the curvature of a panel between curvature measurements made in one direction and the curvature measured at right angles to it seems to be the limit of elasticity. Beyond this point, fracture becomes inevitable.

Figure 12 shows some of the effects created before visual failure, but just after a differential greater than the limit of elasticity had been attained.

Received June 27, 1952. To be presented at the 38th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb 16–19, 1953.

Pulps from Straw and Sugarcane Bagasse for Manufacture of Newsprint

E. C. LATHROP

Newsprint is a generic term used to describe paper of the type generally used in the publication of newspapers. The term "standard newsprint paper" as used in paragraph 1772 of the U. S. Tariff Act of 1930 has been interpreted by the United States Customs Court to be that form, class, or standard of newsprint paper which was chiefly used for printing newspapers on or prior to June 17, 1930. The Treasury Department has defined this paper by definite specifications which are presented on page 237 in "The Dictionary of Paper" published under the auspices and direction of the American Paper and Pulp Association. This definition is particularly important from the standpoint of customs.

For many years before 1890 newsprint was made from straw pulp mixed with rags. After the process of preparing mechanical or groundwood pulp was discovered, this pulp was blended with straw pulp. Not long thereafter, however, the use of straw pulp was supplanted by wood pulp generally made by the sulphite process.

Present-day newsprint is composed of a blend of from 80 to 88% mechanical or groundwood pulp which is produced by grinding bolts of wood on a stone in the presence of water. The yield of such pulp is in the neighborhood of 90 to 95%. Because of the high yield from the wood and the simplicity of manufacture, mechanical pulp represents the lowest-cost source of wood pulp. In order to produce a sheet of paper which can be made on the present high-speed, wide newsprint

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paper machines, it is necessary to add a certain proportion of stronger pulp produced by cooking pulpwood with chemicals. Ordinarily this is spruce or hemlock sulphite pulp.

The characteristics of opacity, ink absorbency, softness, and bulk in newsprint are mainly due to the mechanical pulp. Experience shows that chemical pulp does not have these qualities to the same extent as the mechanical pulp. On the other hand, it is possible to replace the spruce sulphite pulp with a bleached kraft pulp as is done in Australia and also, as we have discovered, with bleached straw pulp and with bleached sugarcane bagasse pulp. All of these chemical pulps have the property of giving a wet sheet strong enough to run through the presses and over the driers in the present high-speed paper machines.

While newsprint paper is considered one of the lower grades of printing papers, it is really a highly specialized product. It is manufactured on the largest paper machines and at the highest production speeds of any of the printing papers. Therefore, consideration must be given particularly to the qualities of the pulp required for such operating conditions. In use, newsprint must run on the modern high-speed printing presses with relatively few breaks. It must be capable of absorbing the cheap news inks rapidly and yet receive sharp impressions of types, cuts, and printing plates without blurring. It must have sufficient opacity so that little or no "show-through" (that is, printing on one side of the paper must not be easily discernible from the other). It must be relatively stable dimensionally for good register in color printing and be relatively clean and sufficiently bright to obtain good contrast and easy reading without eye strain.

Since newspaper advertising pays most of the cost of the daily newspapers, the advertisers are responsible to a considerable extent for those special qualities which have developed in newsprint requirements over the years. The papermakers, in cooperation with publishers, press manufacturers, and ink manufacturers have all contributed notably to the advances in newsprint quality. A change in the paper or in the way ink is absorbed by it will obviously affect its running qualities on the presses, its tendency to smear, its show-through, and other important characteristics.

There have been a number of proposals to make newsprint out of 100% chemically pulped straw or bagasse or even chemical wood pulps, although wood pulps at present are not under consideration because of the pulpwood shortage. The action of chemicals in pulping is to remove from the raw materials certain constituents which are responsible for the particular characteristics of groundwood. Chemically produced pulps all have a different and lower ink absorption than mechanical pulp and, generally, less opacity although opacity can be increased by the use of filler material such as clay. Certainly, pulps can be produced from straw or sugarcane bagasse which can be made into paper of newsprint weight and which would run satisfactorily over the present printing presses. But such paper would not look like or behave like present standard newsprint and changes would have to be made in the types of ink used for printing. In addition, the cost of such paper would tend to level out at a price higher than that of present newsprint; although under emergency conditions, where entirely free markets may not exist, there might be periods during which such 100% straw or bagasse paper could be competitive with standard newsprint. Of course, in countries where mechanical pulps are not available, the publishers might very well be satisfied with a different type of sheet. After all, it is the publisher who will eventually decide whether a product differing from standard newsprint is acceptable to the newspaper trade.

Experiments conducted over the past 3 years by the Northern Regional Research Laboratory group, in cooperation with industry and with the Forest Products Laboratory, have a direct bearing on this subject. The first of these experiments was run at the request of the Ontario Paper Co., Thorold, Ont., who manufacture the newsprint for the Chicago *Tribune* and the New York *Daily News*. The company desired to determine, during the emergency in 1949 when the price of wood pulp was advancing so rapidly, if other raw materials besides pulpwood would be suitable as a supplement in newsprint manufacture. At that time a new chemical process for pulping straw had been developed at this laboratory. The process gave a higher yield of strong pulp than had been obtained by previous methods, and it was used for preparing the straw pulp on a commercial scale at the Ontario mill. This pulp, after screening, was given a mild bleaching treatment and was blended with the standard mixture of mechanical and spruce sulphite pulps to the extent of 17 to 20% of the total pulp used in making the paper. This blend was run on a large, high-speed, modern newsprint paper machine for 7 to 8 hr., producing from 35 to 40 tons of newsprint paper. No changes were required in the paper-machine operation and the straw pulp was entirely satisfactory from the standpoint of manufacturing operation. The paper so prepared was judged to be of somewhat better formation and smoother finish than standard newsprint. It was shipped to the Chicago *Tribune* and run into 163,000 copies of a 28-page edition without a single break on the presses. The printing characteristics of the paper were enough improved over the standard sheet so that is was possible to determine by inspection which paper contained the straw pulp. This run proved definitely that bleached straw pulp can replace all or most of the spruce sulphite pulp as the chemical, strength-conferring constituent in standard newsprint, when used with fresh mechanical groundwood.

This laboratory has entertained for some time the idea that it would be possible during an emergency and, indeed, in normal times to produce newsprint in another manner, using straw or bagasse pulp with deinked waste news. It was proved during World War II that under proper campaigning large amounts of wastepaper could be collected at reasonable costs. For many years a variety of papers, particularly for magazines, have been manufactured by collecting printed magazine papers and deinking these by a chemical process. It is possible to do a satisfactory job of deinking waste printed newspapers. The pulp produced in this manner would supply the mechanical pulp characteristics which are so necessary in the present-day newssheet, and the chemical pulp required for giving the strength characteristics to the sheet could be supplied by the use of chemical straw or bagasse pulp.

In May, 1951, in a cooperative project between the Forest Products Laboratory, Madison, Wis., and the Northern Regional Research Laboratory, Peoria, Ill., straw pulp prepared by a new, streamlined, simple process was blended with unprinted waste newsprint to produce newsprint paper. The straw pulp was obtained by digesting the straw in an open vessel for $\frac{1}{2}$ hr. at about 210°F. The pulp was then washed, screened, and bleached. The yields of straw pulp obtained were high as compared with conventional processes. The paper produced from a blend of 20% of this straw pulp and 80% of the waste unprinted news was produced on the experimental machine of the Forest Products Laboratory. The paper had considerably better formation than is usually found in newsprint and it also had better strength characteristics all around. The color of this paper using bleached straw pulp was considerably lighter than that obtained for the common newsprint. It would appear from this experiment that it is entirely feasible to produce what we would call standard newsprint today from a mixture of deinked waste newsprint and chemical straw pulp.

In order to determine that there would be no difficulty in replacing the softwood sulphite chemical pulp used in manufacturing standard newsprint by either bleached straw or bleached sugarcane bagasse pulp, some further experimental runs were made in a cooperative project between the Forest Products Laboratory and this laboratory in November, 1951.

Newsprint was made from 20 to 30% of bleached straw pulp and bleached bagasse pulp blended with softwood and hardwood mechanical pulps. A control run using 20% softwood sulphite and the same mechanical wood pulps was made for comparison. The newsprint produced from the straw and bagasse pulps blended with the groundwood pulps was fully equal to that produced with the all-wood furnish.

In connection with sugarcane bagasse, the Northern Regional Research Laboratory has under development a process for separating pith from the fibers of such bagasse as it comes from the sugar mill. The presence of pith in sugarcane bagasse ordinarily decreases the yield of pulp, increases the cost of bleaching, and causes a pulp of slower drainage on the paper machine.

To recapitulate, it has been shown that a paper having the properties of standard newsprint may be produced (1) by replacing part of the furnish in standard newsprint by bleached straw pulp; (2) by repulping unprinted newsprint paper and adding to this pulp 20% of bleached straw pulp—this indicates that it should be possible to manufacture satisfactory paper for use by the newspaper publishers by deinking newsprint and using either bleached straw or bleached sugarcane bagasse pulp to supply the chemical pulp required to give the necessary strength and life to the paper; and (3) it is indicated that virgin mechanical pulps made either from the conifers or from the hardwoods can be converted to satisfactory newsprint by the addition of 20 to 30% of either bleached straw or bleached sugarcane bagasse pulps, and this has been determined by trial runs on the experimental paper machine at the Forest Products Laboratory.

What is called standard newsprint cannot be made from 100% chemical pulp from any material, either softwoods, hardwoods, straw, bagasse, or other wastes since the chief properties of newsprint are dependent on the presence of the mechanical pulp. However, it is entirely possible to manufacture papers which can be printed and run on high-speed presses. It is probable that over a period the manufacture of such papers may prove to be more expensive than the manufacture of standard newsprint, and the deciding factor in the use of papers of this type depends on their reception by the public and particularly the willingness of publishers to contract over a period of years for the use of papers of this character.

Paper Machine Fires

G. W. BRAHMST

Early this year a fire originated in a paper machine in a midwestern paper plant. The fire spread rapidly over the machine, into the unsprinklered hood and ventilating stacks above. All combustible material on the entire drying section of the machine, including the felts, was burned. Two hundred bearings were damaged and had to be repoured. Heat cracked the cement asbestos board hood and damaged ventilating stacks. Auxiliary equipment such as motors, wiring, etc., were also damaged. Fifty-seven sprinkler heads at the roof level opened due to the heat of the fire. This fire is believed to have been caused by a hot bearing, probably due to the lack of lubrication, which ignited the paper dust and fibers and oil around the bearing. The estimated amount of damage including loss of use of the machine was $50,000 and this was considered on the low side.

Perhaps many of you are wondering if you could have such a loss in your plants, some maybe wondering how fires in paper machines can be prevented and, if they do occur, how the damage and down time can be kept at a minimum.

Some time ago, at another conference, one of the speakers said, in referring to statistics, that they are more efficient than any sleeping pills. I heartily agree with that statement. Statistics are quite essential and the basis for determining preventative measures. The following are from Factory Mutual records covering about 200 properties having paper machines.

From 1928 to 1949 there have been 395 losses from fires involving paper machines in Factory Mutual insured plants. The total amount of loss resulting from these fires was $843,000 including loss of production which was approximately $270,000. The amount of loss of production would no doubt have been much higher had all of the plants carried use and occupancy insurance. This form of insurance was not carried by many plants prior to about 10 years ago.

During 1950 there were 33 losses involving paper machines. In the nine months of 1951 the record is much better as far as the number of fires is concerned, for there have been only ten machine fires with an estimated loss of approximately $18,000 property damage and $12,000 use and occupancy but the amount of loss for these ten fires about equals that for the 33 fires in 1950. This is due partly to the higher labor and material costs, and to the fact that for several of the fires the amount of loss has been estimated. As a rule estimates are higher than the actual loss.

In these days of astronomical figures, these losses may seem small but to the individual plant operator any loss is of importance. The amount of property damage, even increased by use and occupancy, as paid in dollars does not always show the true picture.

Let us see what causes these losses. Again we find from our records, after a study of 352 fires, that the following were reported by our fieldmen to be causes of these fires.

Fire Causes

Hot bearings	39%
Electrical	18%
Friction	17%
Cutting and welding	7%
Miscellaneous sparks	4%
Static sparks	3%
Hot steam pipes	2%
Smoking	1%
Unknown	7%

Hot bearings cause four out of every ten fires and occur principally on the older type of paper machine having grease or oil lubricated plain type bearings. Because of the inaccessibility of the bearings on the back side while the machine is operating, most of the fires occur on this side of the machine. The presence of grease or oil-covered open gears and oily fibers, paper dust, pieces of paper, rags, and rope add fuel and cause a hot fire once ignition occurs.

We have no record of a fire originating from a hot bearing in the newer type machines having enclosed gears, antifriction-type bearings and with oil supplied from a central lubricating system.

The electrical fires, second in number, are caused by failure to maintain the electrical equipment, particularly the motors, in good repair. Motor bearings, like many others, are frequently overlubricated resulting in oil getting on the windings and power wires. This breaks down the insulation, and also helps dust and fibers to accumulate in the motor. If not removed periodically overheating occurs, followed by failure of the insulation or a short circuit, and then a fire.

Heat generated by friction of paper chokes between rolls, at belts, gears, clutches, and moving parts other than bearings caused the third largest number of losses.

Cutting and welding operations while making repairs or alterations to equipment have been the fourth major cause of fires. Most of such fires are the result of carelessness on the part of both the machine operator and the welders and are due principally to not taking the necessary precautions to clean up the machine and remove or protect all combustible

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material in the vicinity of the welding or cutting operations or, better yet, where possible to move the parts to be welded to a safe location.

Now that we have some idea of the cause of these fires maybe a few actual fire losses might give a better picture of how the fires occur and the damage is done.

We have already cited one example of a hot bearing fire at the start of this paper. Here are a few others.

At one plant a hot bearing in the machine room basement caused a fire which spread through the belt and other openings into the first story. Here the fire flashed over the dust and fiber deposits, oily gears, and the paper on the machine. Sprinklers in the vicinity of the origin of the fire were found, after the fire, to be obstructed with scale, pebbles, and silt. The water supply was poor permitting the spread of the fire which eventually destroyed the entire machine room and adjacent beater building.

At another plant two fires originated at hot bearings on the back side of the machine. An employee observed one of the fires start but before he could obtain extinguishers it had spread over the machine. The hood over the machine was unsprinklered. One fire damaged the lower felt and the other damaged the upper felt. The machine was shutdown for 14 hr. following the fire and most of you realize what a shutdown of such duration can do to your production schedule.

Early this year an employee noticed a hot bearing on a paper machine and tried to cool it by discharging a carbon tetrachloride extinguisher on it. He then proceeded to oil the bearing. When the oil touched the hot bearing it burst into flames which spread over the machine and into the economizer. The fire damaged the building roof and two machine felts.

Fire started at a hot bearing on a newsprint machine, spread over the machine and into an unsprinklered noncombustible hood and economizers. It damaged three or four economizers and the heat exchanger units.

The following are examples of fires from other causes.

A steel shaft on a felt tightener roll broke causing sparks which ignited paper dust and fibers on the machine. The resulting fire was extinguished by sprinklers and hand extinguishers.

While employees were changing a felt an unprotected light bulb broke and the hot filaments ignited the dust and fibers on the machine. The fire flashed over the front of the machine and was extinguished by two sprinklers, small hose, and hand equipment. A little later a smoldering fire was found at the back side of the machine and was quickly extinguished.

To protect a bearing in the basement from water leaking from above, a piece of felt 12 by 16 by $^1/_8$ in. had been laid over the bearing. This piece of felt apparently was drawn into the machine and became lodged between a roll hub and the bearing. The friction created ignited the felt and the fire spread to the loose broke and the paper in the drier and on up into the first story. After the fire pieces of the felt were found tightly wedged in place. An examination of the bearing gave no indication of improper lubrication.

An operator in one plant lighted a match to look into the hand hole of a cylinder. The flame ignited the dust and fibers on the machine and fire flashed over the side of the machine, into the hood and economizer. Ten sprinklers opened over the bearings, two in the economizer and 28 at the building roof. The damage was confined to the economizer house floor, which was torn up to fight the fire, electric wiring, paint on the machine, two asbestos felts, the carrier rope, and asbestos board hood.

Repairs were being made to a paper machine room and some steel beams were being installed with the aid of portable cutting and welding equipment. A spark is believed to have been drawn in a nearby fan intake and it ignited the deposit of fibers and dust on the interior of the duct. There were no clean-out openings in the duct and following the fire an inspection revealed a $^1/_2$-in. thick oily dust and fiber deposit on the interior of the duct. The damage was confined principally to the paper stock.

At another plant making paperboard a fire caused by the ignition of dust and fibers by a welding spark spread to an unsprinklered plenum chamber of a hot air recovery system and damaged the copper tubes of the heater and steel deck roof. Precautions had been taken to plug existing cracks and to station workmen with extinguishers nearby, but in spite of the precautions a spark ignited dust and fibers on a building column and spread across the roof into the plenum chamber.

At a midwestern plant employees were cleaning the hood over a paper machine and had stopped work for lunch. On returning they discovered the entire hood on fire. Flames had spread to the machine, ducts, blower, and economizer. The fire, apparently started by a spark made by the brushes on a portable vacuum cleaner, smoldered and finally burst into flames. Forty sprinkler heads opened in the first story and ten in the basement.

Several fires have started at calenders and flashed back to the machines. One such fire started following a break while paper was being fed by hand into the first calender stack which had just been cleaned with kerosene. The fire started on the machine side of the stock and spread to the machine and the broke in the pit beneath the machine. Nine sprinklers at the roof opened and beat down the fire which was extinguished by means of three small hose lines.

A good example of poor housekeeping and overoiling is shown in a fire that originated in the basement and flashed up the side of the machine and into the hood. The fieldman investigating the fire reported as follows: housekeeping is substandard with excessive oil and grease spillages and run over (excess lubrication) on the side of machines, under floor slab, and on pipes, motors, shafting, etc., in the basement. Numerous oil-soaked wiping cloths are spread about, and broke accumulation on pipes, etc., becomes oil soaked.

The fire was believed to have been caused by the oil-soaked broke in contact with a 150-lb. steam line.

I have tried to show you that fires occur in machines from many causes most of which can be prevented. These are actual cases fires with no spectacular additions for the benefit of the paper.

What can be done to prevent these fires and to reduce the amount of damage done by them? First let us consider what can be done to prevent fires. Without question prevention of paper machine fires is largely a matter of maintenance and good housekeeping.

Most plants today have a good maintenance program which if carried out as intended would greatly reduce the possibility of a fire. However, shortage of help due to the desire on management's part to cut down operating expenses and the difficulty of getting reliable, interested help has reduced the effectiveness of such a program.

Nevertheless good maintenance is essential and machines must not be permitted to wear to the point where they can create a hazard such as in one plant where sufficient end play was permitted to develop in the bearings to permit the drums to strike the frame and cause sparks which ignited the dust and fibers on the machine.

Good maintenance requires checking all bearings on the machine, drive units, and auxiliaries such as pumps and fans, checking the drums, rollers, and felts for alignment. It means the adopting of a lubricating program under the direction of a qualified supervisor. Those of you who purchase your lubrication supplies from one of the large oil companies should, if you have not already done so, have one of the oil company's lubrication engineers familiar with paper mill operations make a study of your needs and give you a list of the recommended lubricants for each machine. You should probably train your mechanics as to the right type and amount of lubricant to use.

As you have often heard, to overlubricate can be as bad as to underlubricate. It is wasteful, costly, and in electrical equipment excess oil has a disintegrating effect on most electrical insulations resulting in short circuits or fires. Over lubrication causes an oil film to form on the machine frame where it collects fibers and dust which can eventually clog oil passages, cause overheating and by capillary attraction drain the oil away from the bearing.

Next to good maintenance is good housekeeping. This involves keeping everything in its proper place and keeping the buildings and machinery clean. Housekeeping is one of those necessary overhead items which can easily be seen on the cost accounting books but from which the benefits are hard to determine in dollars and cents. It does show up, however, in the quality of the product and in employee morale. It is quite unlikely that one will find a dirty, poorly kept plant turning out a top quality product.

To maintain good housekeeping it is necessary to shut down the machine periodically for cleaning and inspection. When the production schedules are heavy and the sales department is calling for more and more paper many plants skip the maintenance shutdown until it is necessary to shut down the machine because of trouble, a breakdown, or a fire. It would be much better to shut the machine down at regular specified periods for cleaning and servicing.

In the past fires in economizers were quite common because of the rapid build-up of dust and fibers and the difficulty of cleaning the units. Due to improvements in design and the fact that most present-day paper mills do not have economizers, there have been few fires in this equipment.

Paper machine fires can be prevented or reduced in number and the extent of damage held to a minimum by the following precautions:

1. Install automatic sprinklers in hoods, ducts, economizers, where used, and over the drive gears of the older type machines. Records show that most paper machine fires originate at the back side of the machine where oil or grease soaked paper dust and fibers accumulate and cannot be removed when the machine is operating. Sparks from a machine fire usually are carried into the hood, ducts, and economizers where they ignite the dust or fibers present. Sprinklers in these areas extinguish the fire or control its spread. The water discharged from the sprinkler heads keeps the ducts, fans, etc., cool, thus preventing structural damage.

Fires in machines under hoods equipped with sprinklers cause less damage and involve a shorter shutdown period. The average loss per fire where sprinklers are lacking or are incomplete amounts to $4380 and where sprinklers are complete it amounts to $557. Some operators fear that the sprinklers may open prematurely or that they will cause condensate to drip on the paper. Leakages reported over paper machines have been less than two a year. The machine felts suffered the greatest damage in these leakages.

Condensation on sprinkler piping under hoods has been given by many machine operators as an objection to the installation of sprinklers. These claims are made without any foundation as an investigation of this at a number of plants having sprinklers showed that no condensation took place. They are apparently based on experiences with piping having water flowing through it whereas a sprinkler system has no circulation and frequently the branch line piping contains only entrapped air. Where there is a fear of condensation the piping can be insulated or located outside the hood with only the heads projecting through to the inside.

Some believe that the hot metal surfaces such as drier drums and particularly the Yankee driers having the large diameter, heavy-wall roll will be damaged by the discharge from sprinklers. For fighting fires in such driers we recommend the installation of sprinklers and the use of hose lines equipped with spray type nozzles. We do not recommend using a solid hose stream on the hot drier rolls. To date on regular paper machines we have no record of any damage being done to a hot drier roll by water discharged by a sprinkler head.

Several years ago the National Safety Council made a study of the subject and published their finds in Engineering Study Pulp and Paper No. 3 "Report on the Use of Sprinklers Under Dryer Hood." The tentative conclusions in the report were that the likelihood of drier rolls fracturing, at least immediately upon operation of sprinklers appeared to be remote but that there was a possibility of damage and subsequent failure.

2. To supplement sprinkler protection, ample small hose connections should be installed in the vicinity of the machine. Sufficient $1^1/_2$-in. diameter cotton rubber lined hose in not over 50-ft. lengths and equipped with a shut-off type combination spray and solid stream nozzle should be provided at each connection so that all parts of the machine room can be reached by one or more streams.

3. Provide adequate portable type extinguishers in readily accessible locations so that in the event of a fire the employees can quickly obtain equipment for combatting it. Portable extinguishers should be of the proper type for the hazard. Where good pressure is available garden-type hose and nozzle have proved to be effective. It is easily handled by one man and therefore can be quickly brought into action by an operator or attendant when a fire is first discovered.

4. If not already in use, institute a regularly scheduled program servicing clean up period for each machine. The time interval between periods will vary with the type of paper or pulp being run in the machine. Where short fiber material is being run or a soft paper is being made frequent cleaning will be necessary.

5. Where possible modern lubricating systems should be installed on the machine bearings. Where manual lubrication is used the employee lubricating the machine should be instructed as to the correct type oil to use and the amount to supply to each bearing. The effect of over oiling should be pointed out.

6. Train all employees in the machine room as a fire fighting crew. Assign to each certain duties to perform in case of fire so that all efforts can be utilized to the utmost to keep the fire from spreading and to quickly extinguish it. All employees should be fully trained in the use of first aid extinguishing methods as effective application can, as has been frequently shown, quickly extinguish a fire with little or no damage.

Frequently in plants we find that the first and second shifts are so trained but that the third shift has had little or no training and is without supervision comparable to that on the other shifts. Therefore this shift is not capable to handle such an emergency as a fire and greater damage results.

7. Establish a permit system for any welding operations to be done in the plant. The work to be welded should be inspected by the foreman or delegated responsible person to determine if it can be taken to a safe location and if not, the area should be inspected and combustible material removed or protected and all paper dust and fibers removed before the permit is issued. While the work is being done and for at least one hour after the work has been completed the area should be patrolled. Particular care should be taken when outside contractors are performing the work.

In closing I have tried to point out the major causes of paper machine fires based on actual experience records. May I suggest that when you return to your plant you do with the the thought in mind that you will make an actual inspection of your machine rooms and machines to eliminate any possible sources of fire which you may have overlooked. As you well know a shutdown of a machine means a loss of production which a plant operating at capacity cannot make up.

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EMPLOYMENT SERVICE

Positions Open

P250-52. An opening exists in the technical staff of midwest mills producing board and corrugating medium. Applicant should be under 35 and have an academic background of chemical engineering or pulp and paper. Unless a '52 graduate, mill experience will be valuable. After a brief training, the man employed will be placed in charge of a mill laboratory. Send detailed experience with photograph.

P253-52. Chemist or Chemical Engineer wanted for sales and service work by company manufacturing and selling adhesives for paper coating and paper converting problems.

P256-53. Pulp and Paper Chemist or Technologist, preferably with some experience in the paperboard industry.

P257-53. Chemical Engineer or graduate of pulp and paper course between 25 and 40 years of age, and should have at least five years' experience in the pulp and paper industry. Salary in the range of $5000 and $5500 per year.

P258-53. Superintendent. 40–45 years of age with considerable experience in papermaking, preferably parchment, glassine, and greaseproof grades.

P259-53. Technically trained man for general work in quality control. Candidate should be qualified later for position of Technical Director of large sulphite and semichemical pulp and paper mill.

P260-53. Technically trained man for research work on new coatings of the lacquer and rubber types.

P261-53. Technically trained man. 25–30 years of age. At least five years' experience in papermaking operating quality control. Opportunity leading to supervision and management for company manufacturing twisted tissue papers.

P262-53. Experienced Sulphite Superintendent for Northeastern Maine newsprint mill. Experience in Chemipulp hot acid system preferred. Some technical training necessary. Reply giving personal history, experience and salary preferred.

P263-53. Recent papermaking or chemical engineering graduate with some technical experience in paper or paperboard desirable. Man selected will be responsible for product and process development work as the member of the technical staff in a progressive integrated midwestern board mill. Excellent advancement opportunities exist. In replying, give complete background of education and experience along with salary requirements.

P264-53. Pulp and Paper Technologist for expediting challenging research and surveys for converting residue products into pulp. Headquarters, San Francisco. Desired age 30 to 40. Salary adjusted for one year minimum contract.

P265-53. Engineering graduate to supervise installation and maintenance of automatic control and recording instruments and to work on steam plant, ventilating and drying problems for the entire mill. Experience in the above fields is desirable.

P266-53. Chemical Engineer to sell chemical lime in New England, New York, and Pennsylvania. Pulp mill experience especially desirable.

P267-53. Coating Chemists, Design Engineers and Physicists. These permanent positions open in research and experimental work as a result of the expansion program of a modern midwest pulp and paper mill laboratory. Our employees know of these openings. Reply giving personal history, experience and salary expected.

P268-53. Formosa. Top-flight pulp and paper man for 2 year contract to carry out large mill's improvement program, including purchase, installation and operation of new machinery. Must be 40 years or older and in good health. Living conditions good. Salary commensurate with ability. In reply give experience and references.

P269-53. Pulp research man for large company in northeast. Ph.D. or M.S. degree desirable. Applicant should have had experience in conducting long-term pulp research. Positions open also for two or three younger men to engage in research.

P270-53. Packaging Engineers—junior and experienced. A large kraft paper manufacturer has openings for graduate engineers, chemical background preferred, for development and technical evaluation of bags, specialty papers and new products. Lab supervision, complaint investigation, technical assistance to paper conversion groups included.

Positions Wanted

E204-52. Paper Mill Superintendent available at once. Capable of handling Yankee or regular fourdrinier paper machines in the manufacture of facials, toilet, or lightweight kraft and sulphite specialties.

E205-52. Experienced Chemical Engineer. Many years in research development on specialty board and wet machine products. Much experience in the graphic arts field. Desires a laboratory position where imagination and creative ability are a prime requisite.

E208-53. Graduate paper chemist. Five years' experience in quality control, research and production. Desires position with a paper converter in the Chicago area.

E209-53. Chemical Engineer. 6 years' experience in an integrated pulp and paper mill with knowledge of laboratory and operations.

E210-53. Cellulose chemist. Ph.D. 18 years' diversified industrial and administrative experience. Research development and production problems, pulp, paper, cellulose derivatives, plastics.

E211-53. Pulp and Paper Chemist with Masters Degree from the New York State College of Forestry. Three years' experience. Publications. Desires position in paper development work or production.

RECENT BOOKS

Encyclopedia of Chemical Technology. Vol. 9. Edited by Raymond E. Kirk and Donald F. Othmer, Polytechnic Institute of Brooklyn. The Interscience Encyclopedia, Inc., New York, 1952. Cloth, $7^1/_2 \times 10^1/_2$, 943 pages. Illustrated. $30.

This volume is the ninth in a series of fourteen volumes. All previous volumes have been reviewed in *Tappi*. The above-mentioned price applies to this volume if purchased separately. Purchasers of the entire set pay $25 per volume.

Volume 9 covers subjects alphabetically from Metal Surface to Penicillin. Included in this volume are such subjects as methanol, mica, chemical microanalysis, microorganisms, chemical microscopy, mixing and agitating, molecular structures, nickel alloys, nomenclature, nomographs, essential oils, organic analysis, packaging, packing materials, paints, paper, paper coatings, patents, and pectic substances. The section on paper was prepared by members of the staff of The Institute of Paper Chemistry and the West Virginia Pulp and Paper Co.

Lange's Handbook of Chemistry. 8th Ed. Edited by Norbert A. Lange and Gordon M. Forker, Sandusky, Ohio. Handbook Publishers, Inc., 1952. $5^3/_8 \times 7^3/_4$, 2000 pages. $7.00.

Since most of the readers of *Tappi* are acquainted with previous editions of Lange, as the handbook is frequently called, like other standard handbooks each new volume of Lange is enlarged with new and increasingly useful data on the physical and chemical properties of classified substances. Of particular interest among the new tables added are the following: titrimetric indicators, molar equivalent of a liter of gas at various temperatures and pressure, and density of moist air.

Chemicals of Commerce. 2nd Ed. By Foster Dee Snell and Cornelia T. Snell. D. Van Nostrand Co., Inc., New York, 1952. Cloth, $5^1/_2 \times 8^1/_2$, 590 pages. $6.50.

The authors, executives of Foster D. Snell, Inc., New York, research and testing consultants, have brought this useful handbook up to date with much new information. The volume is planned to furnish information on the composition of actual commercial products as sold in commerce. It is much more than a chemical dictionary since it gives more details that the authors feel would be of value to production men in industry.

The Chemistry of Synthetic Dyes. Vols. I and II. By K. Venkataraman, Department of Chemical Technology, The University, Bombay, India. Academic Press,

Inc., New York, 1952. Cloth, 6 × 9 (Vol. I, 704 pages, $14.50; Vol. II, 738 pages, $15).

For a quarter of a century K. Venkataraman has worked on the chemistry of natural and synthetic coloring matters and related problems. His present two-volume work fills an important need in bringing together a comprehensive treatise on the subject. In addition to information on the chemistry of intermediates and dyes he features application of dyes, the relation between color and chemical constitution, the action of light on dyes, and the chemical constitution of dyes in relation to their affinity to fibers. Although a large portion of the contents is of primary value to textile chemists a large amount of information is of benefit to paper colorists.

Soluble Silicates. Vol. II. By James G. Vail, Director, The Philadelphia Quartz Co. Reinhold Publishing Co., New York, 1952. Cloth, 6 × 9, 670 pages. $15.

"Soluble Silicates," Vol. I, was reviewed in the November, 1952, issue of *Tappi*. Vol. II is the second part of the American Chemical Society Monograph No. 116. The first volume dealt largely with the theoretical aspects of the subject. Vol. II, while including considerable theory, is devoted largely to the technical applications of silicates. Here are described the film-forming properties of silicates and their use as adhesives, laminates, sizes, fire protection materials, plastics, etc. The use of soluble silicates in the form of gels and their properties as catalysts, protective agents, and stabilizing materials are covered in detail.

Statistical Methods for Chemical Experimentation. By W. L. Gore, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Interscience Publishers, Inc., New York, 1952. Cloth, 4 1/2 × 7 1/4, 201 pages. $3.50.

This book is the first of a series of Interscience Manuals which are being prepared to present important technical subjects as concisely, yet completely as possible. A book, such as this, dealing with statistical methods will be welcomed by technical and production men in industry. Although the subject is now taught to technical school undergraduates, a great majority of the individuals who now find a need to master the subject did not receive such instruction and therefore welcome texts that will provide practical instruction without involving too much study of the underlying concepts of quality control to which college students are now subjected. During the past Summer TAPPI attempted to meet the need of the pulp and paper industry by conducting a two-week course in statistical methods at the University of Maine and will conduct similar courses later at other locations. Many of the texts on the subject deal with the mechanical industries. Mr. Gore's book gets a little closer to the needs of process industries such as paper manufacture. As he points out the primary contribution of statistical methods to chemical experimentation is in methods of designing experiments. The volume covers statistical concepts of distribution, the reliability of estimates, the analysis of variance, design of experiments, correlation and regression and attribute statistics. The subject is not an easy one to master but its value will make the effort to do so worth while.

91 Paper Making Fibers. Revised Ed. By Charles H. Carpenter and Lawrence Leney, State University of New York, College of Forestry, Syracuse, N. Y., 1952. 5 1/4 × 8 1/2, 152 pages, spiral plastic bound paper cover. $2.00. (Obtainable directly from the College of Forestry.)

Many individuals and companies in the pulp and paper industry obtained copies of the original edition of Dr. Carpenter's "Atlas of Paper-Making Fibers" (1932). The revised edition has been issued in very convenient form. The volume includes 382 photomicrographs of 86 fibers of plant origin, plus wool, silk, asbestos, rayon, and nylon fibers, of value to technicians who have occasion to identify cell constituents of pulp and paper. Included in the description of the 86 fibers are 35 coniferous woods, 35 hardwoods, and 16 cell types of herbaceous plants of interest to the papermaker. To obtain the highest reproduction fidelity, the photomicrographs were printed by collotype, a screenless process. This process permits examining the fiber structure with a hand lens without the distorting influence of a screen pattern.

Introduction to Stuff Preparation for Paper Making. By Leslie G. Cottrall, Albert E. Reed & Co., Maidstone, England. Charles Griffin & Co., Ltd., London, 1952. Cloth, 5 1/2 × 8, 185 pages. $3.50 ($3.85 in Canada).

Mr. Cottrall is a former Chairman of the Technical Section, British Paper & Board Association. In his preface Mr. Cottrall states: "Textbooks on papermaking have in the past confined themselves to empirical descriptions of the functions of plant and processes. When, however, it came to dealing with ultimate causes underlying these functions and processes, textbooks usually resorted to special theories which were applied to individual cases. These theories were unrelated to each other and often were mutually inconsistent. The same thing to a great extent can be noted in the technical literature appertaining to papermaking."

The book is written, with the understanding by the author that many readers will not have had much experience in the industry. Following six preliminary chapters describing the nature of fibers and pulp and the general pulping processes he proceeds to a discussion of defibering, fibrillation, action of water, tear, translucency of paper, cutting or free beating, selection of beaters, beating control, wetting, refiners, and quantitative effects of beating. Later, the author promises to prepare a more advanced text.

Mr. Cottrall is to be commended for taking the time and trouble to prepare a book of this type. The industry needs more monographs dealing with the various aspects of the papermaking processes. R. G. M.

Wood Chemistry. 2nd Ed. Vols. I and II. By Louis E. Wise, Institute of Paper Chemistry, Appleton, Wis., and Edwin C. Jahn, College of Forestry, State University of New York, Syracuse, N. Y. Reinhold Publishing Co. New York. Cloth, 6 × 9 (Vol. I, 720 pages, $15; Vol. II, 665 pages, $15).

"Wood Chemistry" by Wise has long been a "must book" for the libraries of the pulp and paper industry. Now, in collaboration with Professor Jahn the work has been expanded into two volumes. Many chapters are entirely new and the other chapters appearing in the first edition have been completely rewritten from a new and fresh approach.

Volume I deals with growth, anatomy, and physical properties of wood, the components and chemistry of the cell wall, and the extraneous components of wood. Volume II deals with the surface properties of wood, its chemical utilization, biological decomposition, and chemical analysis.

The books are designated as Monograph No. 97 of the American Chemical Monograph Series. Twenty contributors, many who are members of TAPPI, participated in the preparation of the two volumes, especially the chapters on cellulose and lignin and the various pulping operations. An excellent subject index adds much to the reference value of "Wood Chemistry."

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Babcock & Wilcox Co. ..... 41 A
Beloit Iron Works ..... 1 A
Bird Machine Co. ..... 73 A
Black-Clawson (Shartle & Dilts) ..... 7 A
Bolton & Sons, Inc., John W. ..... 23 A
Buffalo Electro-Chemical Co., Inc. ..... 15 A
Buffalo Pumps ..... 27 A
Butterworth, H. W. & Sons Company ..... 75 A

Chicago Bridge & Iron Co. ..... 8 A
Combustion Engineering-Superheater, Inc. ..... 32 A
Curlator Corp. ..... 19 A

Dorr Co. ..... 31 A
Dow Corning Corp. ..... 77 A
Draper Brothers Co. ..... 62 A
Du Pont de Nemours & Co., Inc. (Electrochemicals) ..... 43 A
Du Pont de Nemours & Co., Inc. (Quilon) ..... 9 A

Ebasco Services, Inc. ..... 80 A

Farrel-Birmingham Co., Inc. ..... 49 A
Fawick Airflex Division—Federal Fawick Corporation ..... 13 A
Foxboro Co. ..... 52 A–53 A

General Dyestuff Corporation ..... 35 A
Goodyear Tire & Rubber Co., Inc. (Chemical Div.) ..... 3 A

Heppenstall Co. ..... 14 A
Hercules Powder Co. ..... 2nd Cover
Hermann Manufacturing Co. ..... 78 A
Hooker Electrochemical Company ..... 37 A

International Nickel Company ..... 2 A

Jackson & Church Co. ..... 57 A
Johns-Manville Corp. (Celite) ..... 63 A
Jones & Sons, E. D. ..... 33 A

Kelco Co. ..... 25 A

Lodding Engineering Co. ..... 39 A

Magnus Chemical Co. ..... 81 A
Mallinckrodt Chemical Works ..... 82 A
Mathieson Chemical Company ..... 55 A
Midwest-Fulton Machine Co. ..... 83 A
Monsanto Chemical Co. (Merrimac Div.) ..... 17 A

National Aniline Division (Allied Chemical & Dye) ..... 69 A
Noble & Wood Machine Co. ..... 21 A
Nopco Chemical Co. ..... 36 A

Pennsylvania Salt Mfg. Co. ..... 45 A
Perkins, B. F. & Son, Inc. ..... 80 A
Philadelphia Quartz Co. ..... 150 A
Pusey & Jones ..... 70 A

Reichhold Chemicals, Inc. ..... 61 A
Reliance Elec. & Eng. Company ..... 29 A
Rice Barton ..... 4th Cover
Rohm & Haas Co. ..... 51 A
Roots-Connersville Blower (Dresser Industries Inc.) ..... 74 A

Sandy Hill Iron & Brass Works ..... 59 A
Smith Corp., A. O. ..... 65 A
Solvay Process Div. (Allied Chemical & Dye Corp.) ..... 47 A
Sprout-Waldron ..... 67 A
Stebbins Engineering & Manufacturing Company ..... 34 A
Swenson Evaporator Co. (Whiting Corp.) ..... 48 A

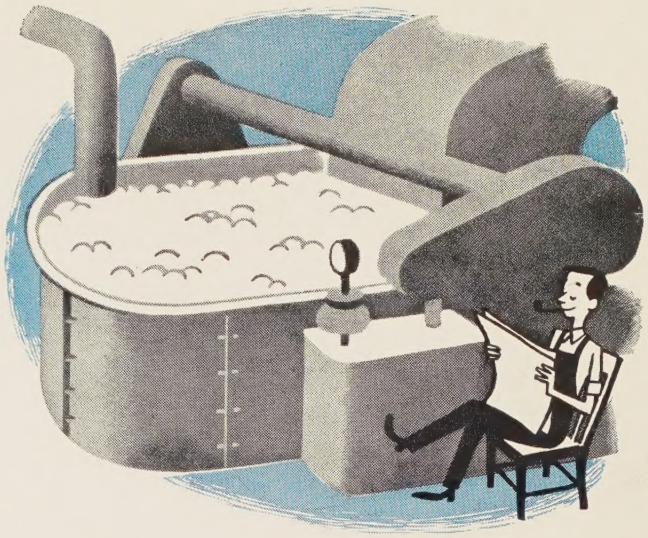
Taylor-Stiles & Co. ..... 68 A
Tennessee Corp. ..... 76 A
Testing Machines, Inc. ..... 78 A
Thwing-Albert Instrument Co. ..... 83 A
Torrington Co., The (Bantam Bearings Div.) ..... 4 A

Vanderbilt, R. T. Co., Inc. ..... 11 A

Wallace & Tiernan Co., Inc. ..... 6 A
Wallerstein Co. ..... 82 A

PROFESSIONAL SERVICES

American Defibrator, Inc. ..... 149 A
Chemical Linings Inc. ..... 149 A
Chicago Testing Laboratory ..... 149 A
Grellet N. Collins ..... 149 A
The H. K. Ferguson Company ..... 149 A
Gilbert Associates, Inc. ..... 149 A
G. D. Jenssen Co., Inc. ..... 149 A
Knowles Associates ..... 149 A
Chas. T. Main, Inc. ..... 149 A
Myers & Addington ..... 149 A
Roderick O'Donoghue ..... 149 A
Paper and Pulp Testing Laboratories ..... 149 A
Pfeifer & Shultz ..... 149 A
J. E. Sirrine Co. ..... 149 A



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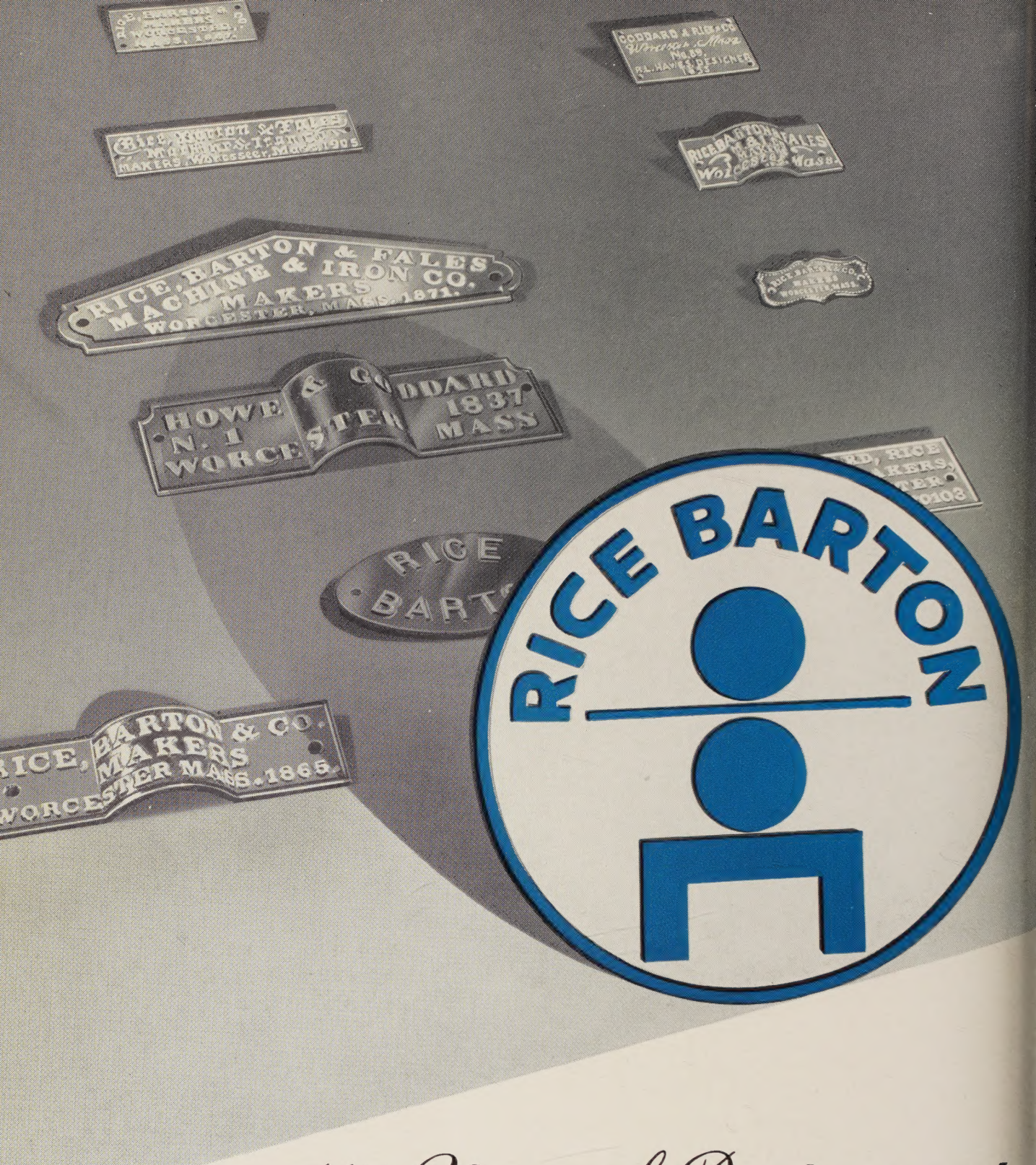

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